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ASTRO-THEOLOGY

Or, A DEMONSTRATION of the
BEING and ATTRIBUTES
OF

GOD,

FROM A

SURVEY
OF THE
HEAVENS.

Illuſtrated with COPPER PLATES.

By W. DERHAM, Canon of *Windſor*, Rector
of *Upminſter* in *Eſſex*, and F. R. S.

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MVSEVM
BRITANNICVM

To his ROYAL HIGHNESS

GEORGE,

Prince of WALES, Prince Electoral of *Brunſwick-Lunenburg*, &c.

Duke of *Cornwall* and *Rothſay*, Duke and Marqueſs of *Cambridge*, Earl of *Cheſter*, *Milford-Haven*, and *Carreck*, Viſcount *North-Allerton*, Baron of *Tewksbury* and *Renfrew*, Lord of the Iſlands, and Steward of *Scotland*, and Knight of the moſt Noble Order of the *Garter*.

Great SIR,

YOUR *Royal Highneſs* having done me ſo great an Honour as to take this Book under your Patronage, with great Humility and Thankfulneſs I lay it at your Feet; not doubting but that (whatever my Performance is) the Subject will be acceptable, it being a Vindication of the *Exiſtence* and *Attributes* of that infinite BEING, to whom your *Royal Highneſs* hath no leſs piouſly than juſtly aſcribed your great Royal FATHER'S and your *Family*'s peaceable Acceſſion to the Crown and Dignity of theſe Realms.

THAT the Bleſſings of the ſame moſt merciful

BEING may be perpetuated to your *Royal Highneſs* and all *Yours*, is the hearty Prayer of,

Moſt Illuſtrious SIR,

Your *Royal Highneſs*'s

Moſt humble

Obedient Servant,

W. Derham.

TO THE

READER.

NOtwithſtanding that a Book is more complete and valuable by Additions and Amendments, yet I think that many and great Additions are an hardſhip and injuſtice to the Purchaſers of a former Edition; and therefore have in this, and in the foregoing Editions, avoided it as much as well I could, although ſome of my learned Friends would have perſuaded *me to it, and alſo contributed their Obſervations.*

But yet from what I have ſaid in the Preliminary Diſc. p. 3. *it will, I doubt not, be expected, that I ſhould give ſome account of the Obſervations which the long and good Glaſſes in my Hands have afforded me ſince the laſt Edition of this Book.*

But I have little to boaſt of here, having (beſides the old former Complaint of the want of a long Pole to manage Mr. Huygens's *Glaſs with) many great hindrances in my Obſervations, partly by a very dangerous Fit of Sickneſs, which hung long about me; and partly by my neceſſary Affairs calling me to matters of another nature. But ſome of the moſt conſiderable of my Obſervations were theſe.*

1. *Viewing* Venus *with* Mr. Huygens's *Glaſs divers nights, when near her Perigee, and much horned, I*

thought I ſaw Anfractus, *or* Roughneſſes *on the concave part of the enlightened edge* (*ſuch as we ſee in the New Moon*) *which I have repreſented as nearly as I could in* Fig. 12.

2. *In my frequent views of* Jupiter, *I find his* Belts *to have great variations; that they change their places; that their Breadths alter, being ſometimes broader, ſometimes conſiderably narrower; that ſometimes they are more in number, ſometimes fewer; ſometimes they are darker and blacker, ſometimes thin and only like a Miſt. Towards the Poles of* Jupiter *are the greateſt Alterations, there being ſometimes few, or no* Belts *toward one or the other Pole; ſometimes one quite acroſs the Polar Parts, another reaching but half, or a part of the Way. And even about the middle, or Equatorial Parts of* Jupiter, *where there are always* Belts (*and commonly two*) *yet theſe vary conſi-*

conſiderably. Sometimes they are nearer one another, ſometimes farther aſunder: ſometimes they are conſiderably broader, eſpecially that neareſt the middle; ſometimes as conſiderably narrower: ſometimes they both advance towards one Pole, and then recede towards the other oppoſite Pole. Of many of theſe Appearances I took Draughts, and deſigned to have enquired whether they had certain Periods; but want of health and leiſure prevented me.

And not only the Belts, *but the* Spots *alſo of* Jupiter *vary greatly; I do not mean the* Spots *occaſioned by the Shade of the* Satellites, *but ſuch as are on the very Disk, which are ſometimes of one form, ſometimes of another, and oftentimes none to be ſeen at all, although the ſame Face of* Jupiter *ſhould be towards us.*

3. The laſt thing I ſhall mention is the Nebuloſe, *which are thoſe glaring whitiſh appearances, ſeen with our Teleſcopes in* Andromeda'*s* Girdle, Hercules'*s* Back, Antinous'*s* Foot, Orion'*s* Sword, *in the* Centaur, Sagittary, *&c. which appear through the Teleſcope ſomewhat after the manner as* Cor Cancri *doth to the naked Eye.*

Theſe Nebuloſe *I have often viewed with Glaſſes of very different lengths, particularly that in* pede Antinoi *with Mr* Huygens'*s: but I confeſs that I could never diſcern what they are; neither indeed could I perceive any great difference in their appearances through a very good Glaſs of about* 14 *foot, and others of* 30 *and* 40 *feet, yea, Mr.* Huygens'*s of* 126.

But indeed the grand obſtacle to all my Views with Mr. Huygens'*s Glaſs was the Vapours near the Horizon, which not only obſcured the Object, but*

but cauſed ſo great a trembling and dancing thereof, as made it no leſs difficult to be diſtinctly and accurately viewed, than a thing held in the hand is, when danced and ſhaken backwards and forwards. By this means my Expectations from Mr. Huygens's *Glaſs were frequently fruſtrated, excepting in nights that were more than ordinarily ſerene and clear, which was commonly in ſuch as were the moſt intenſely froſty and cold.*

Finding it therefore unlikely that I ſhould do much more with Mr. Huygens's *Glaſs than I had done, I reſtored it to the* Royal Society *which lent it me, (and to whom* Mr. Huygens *bequeathed it by his laſt Will) contenting my ſelf with the Views it had given me, and that I had diſcovered it to be an excellent Glaſs, which* Dr. Hook, *and ſome others of our beſt Judges, took to be good for nothing.*

And now having given this account of my Obſervations, and alſo ſhewed what hinder'd my completing of them (which may excite farther Enquiries, as well as ſerve to vindicate my ſelf) I ſhall recommend theſe things to ſuch as have good Glaſſes, particularly to the Diligence and Accuracy of my very ingenious Friend, the Reverend Mr. Pound, *into whoſe Hands the* Royal Society *have put that noble Bequeſt of* Mr. Huygens, *and who is ſo well accommodated for raiſing and uſing that Glaſs, as to have ſeen (among other conſiderable things) the five* Satellites *of* Saturn; *which I confeſs I could never reach, nor above three of them, that I could be ſure were* Satellites: *I ſay that I could be ſure were ſuch, becauſe it is not very eaſy to diſtinguiſh which are* Satellites, *and which are ſmall* Teleſcopick Stars, *which very frequently ſhew themſelves in a Glaſs of ſuch goodneſs as that is.*

I remember that I once verily thought I had found out ſeven Satellites *of* Saturn, *with this very Glaſs of Mr.* Huygens, *ſo regularly were they placed in reſpect of* Saturn. *But when I came to examine them the following nights, I found that there were really no more than two* Satellites, *the reſt being ſmall Fixt Stars. But Mr.* Pound's *Skill and Exactneſs in ſuch Obſervations, is I know ſo great, (and I may add that of my ſagacious friend Dr.* Halley *too, who I hear hath ſeen the ſame) that I do not ſay this by way of Caution to them, although it may ſerve as ſuch to many others.*

And now for a Cloſe I ſhall take this opportunity of publickly owning, with all honour and thankfulneſs, the generous Offer made me by ſome of my Friends, eminent in their Stations, as well as Skill and Abilities in the Laws, who would have made me a

Preſent of the May-pole *in the* Strand, *(which was to be taken down) or any other Pole I thought convenient for the management of* Mr. Huygens's *Glaſs. But as my incapacity of accepting the favour of thoſe noble* Mecœnates, *hath been the occaſion of that excellent Glaſs being put into better hands, ſo I aſſure my ſelf their expectations are abundantly anſwered, by the number and goodneſs of the Obſervations that have been and will be made therewith.*

THE

CONTENTS

Of the following

Preliminary Diſcourſe.

THE *Author's Glaſſes and Obſervations.* Page 2
Of the Ptolemaick *Syſteme.* 6
Of the Copernican *Syſteme.* 7
By whom cultivated. 9
Why preferred by the Author. 10
Objections againſt it from Scripture. 18
Anſwered. 20
Of the Sun's Receſs. 28
Objections from Senſe anſwered. 31
Objections from Philoſophy *anſwered.* 32
Of the New *Syſteme.* 37
Why moſt favoured by the Author. 42
Fixt Stars are Suns. 43
The Author's Opinion about the Whiteneſs of the Galaxy. ibid.

The

CONTENTS.

The Author ſuſpects there are more New Stars *than ever yet have been taken notice of.* Page 44
His Obſervations of them. 46
How to be obſerved. ibid.
The Planets are Worlds. 47
Mr. Huygens *denies Seas being in the* Moon. 48
The Author's Proof and Obſervations of them. 52
What Creatures inhabit the Planets. 56

A
Preliminary Diſcourſe
CONCERNING
The Syſtemes of the Heavens, the Habitability of the Planets, and a Plurality of Worlds, uſeful for the reading of the following Book.

MY *Phyſico-Theology*[a] having met with ſo quick a Sale as to come to a third Impreſſion before the Year was expired, but eſpecially the Solicitations of many Learned Men, both known and unknown, have given me great encouragement to fulfil my promiſe, in ſending abroad this other Part, relating to the *Heavens*: which ſhould ſooner have ſeen the light, but that I was minded not to interrupt the Reader's patience with many Notes (which I could not well avoid in my *Phyſico-Theology*, and which my Rough Draught of this was burthened with) and therefore I threw the greateſt Part of them into the Text: which neceſſitated me to tranſcribe the whole. And when my Hand was in, I new-made ſome part of it, and added many new Obſervations of my own, which I then had lately made with ſome very good long Glaſſes I had in my hands; one of *Campani*'s grinding; and others of *Engliſh* work, which exceeded it; but eſpecially one of Mr. *Huygens*'s of above 120 feet, which few for goodneſs do ſurpaſs.

Of theſe Obſervations the Reader ſhould have met with many more (and I believe ſome of my ingenious Friends do expect more) but that I lie under two inconveniences: One the want of an open free Horizon, my Habitation being ſurrounded much with Trees. The other, and indeed the chief, the want of a long Pole of 100 or more feet, to raiſe my long Glaſs to ſuch an height, as to ſee the Heavenly Bodies above the thick Vapours; which much obſcure all Objects near the Horizon, eſpecially when viewed with ſuch long and good Glaſſes. But ſince that, two very dangerous fits of Sickneſs, and the increaſe of my Age, (both which have much impaired my Sight) have rendered me uncapable of ſuch Obſervations, eſpecially at ſuch Seaſons of the Night and Weather, as are fitteſt for viewing the Heavenly Bodies.

And therefore if I have not ſufficiently anſwered the expectations of ſome of my learned and ingenious Friends, I hope they will excuſe me, and believe it to be more my Calamity than Fault that I have done no more; eſpecially among ſuch Planets as have advantageouſly preſented themſelves, as *Saturn* particularly hath, whoſe 5 or more *Satellites* it may be expected I have ſeen; but I could never reach but three of them, and they only when there were but few Vapours. And as for the Spots in *Mars* and *Venus*, and their Motion round their own Axes, after I had a good Furniture of excellent Glaſſes, I had not any good Views of thoſe Planets before my Sickneſs, by reaſon of the too great diſtance of *Mars* from the Earth, and the proximity of *Venus* to the Sun, and the cloudy Weather, and the ſmall Altitude which *Venus* had above the Horizon about that time.

But however what is here wanting in my own, is ſufficiently made up from the Obſervations of others. Of which the learned World hath good Store, ſince the Invention of the Teleſcope; which as it hath made ample diſcoveries of the Works of God, ſo hath laid open a new, and a far more grand and noble ſcene of thoſe Works than the World before dreamt of, and afforded us a far more rational Syſteme of the Heavens and the Univerſe, than was before entertained.

And foraſmuch as I have frequent occaſions in my following Book to ſpeak of, and, according to ſome or other of the Syſtemes of the Heavens, it is neceſſary I ſhould, by way of Preface, give ſome account of them, to enable ſuch Perſons to underſtand my Book as are unacquainted with Aſtronomical Matters.

Among all the various *Syſtemes*, I need take notice only of three, the *Ptolemaick*, the *Copernican*, and the *New Syſteme*. Of each of which in their Order.

Of the Ptolemaick *Syſteme.*

In the *Ptolemaick Syſteme* the Earth and Waters are ſuppoſed to be in the Center of the Univerſe; next to which is the Element of *Air*, and next above that is the Element of *Fire*; next that the Orb of *Mercury*, then that of *Venus*, then that of the *Sun*; and above the Sun's Orb, thoſe of *Mars*, *Jupiter*, and *Saturn*; and above them all, the *Firmament* or Orb of the *Fixt Stars*; then the *Cryſtalline Orbs*; and laſtly the *Cælum Empyreum*, or *Heaven of Heavens.* All theſe maſſy Orbs, and vaſt Bodies born by them, are, in this Syſteme, ſuppoſed to move round the terraqueous Globe once in 24 hours : and beſides that, in ſome other certain periodical Times. For the effecting of which Motions, they were forced to contrive ſuch Circles as they called *Eccentricks* and *Epycicles*, croſſing and interfering with one another ; which I could not repreſent in ſo narrow a compaſs as *Fig.* 1. is, which is a Scheme of this *Ptolemaick Syſteme* ; which is univerſally maintained by the *Peripatetick* Philoſophers.

Of the Copernican *Syſteme.*

The next *Syſteme* is the *Pythagorean* or *Copernican*, being invented, as ſome imagine, by *Pythagoras* himſelf. But *Diogenes Laertius* (*a*) expreſly ſaith, That *Pythagoras*'s opinion was, *That the World was*

(*a*) Lib. 8. in Pythagorâ.

round, containing the Earth in the midſt of it. And by *Pliny*'s account (*b*) of *Pythagoras* his Diſtances, and Orders of the Planets, this ſeems to have been his opinion. But the ſame *Laertius* (*c*) affirms *Philolaus* the *Pythagorean*, Τῆν Γῆν κινεῖσθαι κατὰ Κύκλον, πρῶτον εἰπεῖν· ὁι δὲ, Ἱκέταν Συρακȣ́σιον φασὶν· *to have been the firſt that ſaid the Earth was moved in a Circle: but ſome ſay* Hicetas *the* Syracuſian. So *Plutarch*, in his *Life of Numa*, ſpeaking of *Numa*'s building *the Temple of* Veſta, ſaith, *he built it round, and that a continual Fire was kept therein in imitation of the Figure of the Earth, or rather of the whole World it ſelf, the middle of which the* Pythagoreans (not *Pythagoras*) *take to be the Seat of Fire.*

This Syſteme (whoever was the Inventer of it) *Copernicus* a *Canon*

(*b*) Nat. Hiſt. L. 2. c. 21, 22.
(*c*) Ibid. in Philolao.

of *Tourain* reſtored about the beginning of the fifteenth Century, and was followed therein by many conſiderable men, as *Rheticus*, *Mæſtlinus*, *Kepler*, *Rothman*, *Bullialdus*, *Lanſberge*, *Herigonius*, *Schickard*, *Gaſſendus*, *Galilæo*, and others. The laſt of which (by the ill will and inſtigation of Pope *Urban* VIII. as 'tis ſuppoſed) had the misfortune to fall under the cenſure of, and to have his *Copernican Tenets* condemned by, the Inquiſition, and was forced to abjure them. The particulars of which, if the Reader hath a mind to ſee, he may find them in *Riccioli*'s *Almageſt* (*d*).

According to this Syſteme, the *Sun* is ſuppoſed to be in the Center, and the Heavens and Earth to revolve round about him according to their ſeveral Periods: Firſt, *Mercury* in

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(*d*) Lib. 9. Sect. 4. Cap. 40.

near 88 days; then *Venus* in ſomewhat above 224 days; then the *Earth* with its Satellite the *Moon*, in 365 $\frac{1}{4}$ days; then *Mars* in about 687 days; then *Jupiter* with his four Moons in about 4333 days; and laſtly, *Saturn* in ſomewhat above 10759 days, with his 5 or more Moons revolving about him. And beyond, or above all theſe, is the *Firmament*, or the Region of the *Fixt Stars*, which are all ſuppoſed to be at equal diſtances from their Centre the Sun.

This is the *Copernican Syſteme*, which I have given a Scheme of in *Fig.* 2. And ſo far as this Syſteme relates to the Motion of the Earth, and the Sun reſting in the Centre, I prefer it to the *Ptolemaick Hypotheſis* on theſe *Five* following accounts:

1. Becauſe it is far more agreeable to Nature, which never goes a

round-about way, but always acts by the moſt compendious, eaſy and ſimple methods. And in the *Copernican* way, *that* is performed by one, or a few eaſy Revolutions, which, in the other way, is made the work of the whole Heavens, and of many ſtrange and unnatural Orbs. Thus the Diurnal Motion is accounted for by one Revolution of the Earth, which all the whole Heavens are called in for, in the other way; So for the Periodical Motions of the Planets, their Stations, Retrogradations and direct Motions, they are all accounted for by one eaſy, ſingle Motion round the Sun, for which, in the *Ptolemaick* way, they are forced to invent divers ſtrange, unnatural, interfering *Eccentricks* and *Epicycles*: An Hypotheſis ſo bungling and monſtrous, as gave occaſion to a certain King to ſay, *If he had been of God's Council when he made the*

the Heavens, he could have taught him how to have mended his Work.

2. As the *Copernican* is far more eaſy and agreeable to Nature than the *Ptolemaick* Syſteme, ſo it is far more complete, and anſwerable to the various Phænomena of the Planets; ſeveral of which the *Ptolemaick* Hypotheſis either very aukwardly ſolves, or doth not at all come up to. I might inſtance here in divers particulars relating to *Venus* and *Mercury*, as why the Earth is never between them and the Sun, which the *Ptolemaick* Syſteme gives no tolerable account of, and but poor accounts of other of their Phænomena, as alſo of thoſe of the Moon and the other Planets. I might ſhew alſo how incoherent and improper the Motions aſſigned to the Heavenly Bodies are in the *Ptolemaick* way, as that the Moon ſhould move round once in a Month, the other

Planets in ſuch and ſuch Periods as are aſſigned to them; the Firmament, or Fixt Stars, in 25 or 26000 years; the Sphere beyond that in 1700 years; the Tenth Sphere in 3400 years; and the outermoſt of all, the *Primum Mobile*, which moves all the reſt in only 24 hours. Which are Motions ſo unproportional, and diſagreeable, that are ſufficient to ſubvert the whole Hypotheſis. But it would be endleſs to enter into a detail of ſuch incoherences and improprieties as the *Ptolemaick* Syſteme abounds with.

3. The prodigious and inconceivable Rapidity aſſign'd by the *Ptolemaicks* to the Heavens, is by the *Copernican* Scheme taken off, and a far more eaſy and tolerable Motion ſubſtituted in its room. For is it not a far more eaſy Motion for the Earth to revolve round its own Axis in 24 hours, than for ſo great

a number of far more maſſy, and far diſtant Globes, to revolve round the Earth in the ſame ſpace of time? If the Maintainers of the *Ptolemaick* Syſteme do object againſt the Motion of the Earth, that it would make us dizzy, and ſhatter our Globe to pieces, what a precipitant, how terrible a Rapidity muſt that of the Heavens be; What a Velocity muſt the Sun have to run its courſe, at the diſtance of 21 or 22 Semidiameters of the Earth? What a Velocity muſt that of the Fixt Stars, eſpecially that of the *Primum Mobile* be, at far greater diſtances than the Sun is?

4. It is an inconteſtible argument of the Sun being the Center of the Planets about him, and not the Earth, that their Motions and Diſtances reſpect the Sun, and not the Earth. For with regard to the Sun, the Primary Planets have a very due Motion, in proportion to their ſeveral

Diſtances; that is, Their Motions round the Sun, are in ſeſquiplicate Proportion to their Diſtances from him: but this Proportion doth not hold at all with relation to the Earth. But as for the Secondary Planets, round *Saturn*, *Jupiter* and the *Earth*, it is very certain that they have the ſame reſpect to their Primaries, as theſe Primaries have to the Sun; that is, *The Squares of their Revolutions are as the Cubes of their Diſtances.* And as it is very certain and viſible, that the Secondary Planets reſpect their Primaries as their Centers, and move round them, ſo it is in ſome meaſure (one would think) no leſs certain, and beyond doubt, that all the Primary Planets which have the ſelf-ſame reſpect to, and Motion with regard to the Sun, as thoſe Secondaries have to their Primaries, that thoſe Primaries, I ſay, do move round him as their Center, and not about the Earth, to whom they have no ſuch reſpect.

5. The laſt Argument I ſhall alledge for my preference of the *Copernican* to the *Ptolemaick Syſteme* is from the great Parity and Congruity obſervable among all the works of the Creation; which have a manifeſt harmony, and great agreement with one another.

Thus in our preſent caſe, it is manifeſt to our ſight, that every Globe we have any good views of, hath ſuch like Motions, as thoſe are which we aſcribe to the Earth. The Sun indeed being in the Center, is as 'twere fixt there, and hath no periodical Motion: but yet the other Motion round its own Axis, we can manifeſtly diſcern. And as for all the Planets which move round about the Sun, they have, as far as 'tis poſſible for us to ſee them, ſuch Motions as thoſe we aſcribe to the Earth;

namely, a Diurnal Rotation round their own Axes, and a periodical Revolution round the Sun. And if this be manifeſt in the other Planets, what ſhould hinder its being ſo in our own? Why ſhould ours be ſingular? Why not be ſuppoſed to be moved as well as the reſt, when it is very certain that either it hath thoſe Motions, or the Heavens have ſo; and it is far more natural and eaſy for the Earth to perform them, than for the Heavens, as hath been already ſhewn.

Thus having ſhewn how far more probable the *Copernican* Syſteme is than the *Ptolemaic*, ſo far as it relates to the Motions of the Heavens and Earth, and the Sun being in the Center, it remains (before I proceed to the *Third* and laſt Syſteme) that I ſhould anſwer ſome Objections alledged againſt this Syſteme, partly from *Scripture*, and partly from *Philoſophy* and *Sight.*

The Objections from *Scripture* are ſuch as ſeem to aſſert the Immobility and Reſt of the Earth, and the Motion of the Sun and Heavenly Bodies.

The Texts that are brought to prove the Immobility and Reſt of the Earth, are, 1 *Cron.* 16. 30. *The World ſhall be ſtable, that it be not moved.* The ſame is ſaid, *Pſal.* 93. 1. *The World alſo is eſtabliſhed, that it cannot be moved.* And ſo the ſame again, *Pſal.* 96. 10. In *Pſal.* 104. 5. GOD is ſaid to *lay the foundations of the Earth, that it ſhould not be moved for ever.* And laſtly, *Solomon, Eccleſ.* 1. 4. aſſerts, that *The Earth abideth for ever.* Like to which is that of the *Pſalmiſt*, Pſal. 119. 90. *Thou haſt eſtabliſhed the Earth, and it abideth.* Theſe are the principal Texts which ſeem to aſſert the Immobility and Stability of the Earth.

The principal Texts which mention the Motion of the Sun and Heavenly Bodies, are ſuch as aſcribe Riſing, Setting, or ſtanding ſtill to them. Thus *Gen.* 19. 23. *The Sun was riſen upon the Earth, when Lot entered into Zoar.* And *Gen.* 15. 17. *When the Sun went down, and it was dark, a ſmoaking Furnace,* &c. So *Eccl.* 1. 5. *The Sun ariſeth, and the Sun goeth down, and haſteth to the place where he aroſe.* So *Pſal.* 19. 5, 6. the Sun is ſaid to *come out of his Chamber like a Bridegroom, and to rejoice as a ſtrong man to run a race.* That *his going forth is from the end of the Heaven, and his circuit unto the ends of it.* Purſuant to which expreſſions of the *Sun's moving,* it is ſaid alſo to *ſtand ſtill,* and to *go backwards.* Thus *Joſh.* 10. 12, 13. *Sun, ſtand thou ſtill upon* Gibeon, *and thou Moon in the Valley of* Ajalon. *And the Sun ſtood ſtill, and the Moon ſtayed.*

ſtayed.——So the Sun ſtood ſtill in the midſt of Heaven, and haſted not to go down about a whole day. And in 2 *Kings* 20. 10. and *Iſai.* 38. 8. the *Sun is* ſaid *to have returned ten degrees backward* in one of the places, and *its Shadow* to have done ſo in the other.

Theſe are the chief Texts of *Scripture*, which ſeem to lie againſt the *Copernican* Hypotheſis. In anſwer to which, this may be ſaid in general to them all; That ſince the deſign of the holy Writings is not to inſtruct Men in Philoſophical, but Divine Matters, therefore it is not neceſſary to reſtrain the Senſe of thoſe Texts to the ſtrict propriety of the Words, but take them to be ſpoken according to the appearance of things and the vulgar notions and opinions which men have of them, not according to their reality, or Philoſophical verity. Thus in divers other inſtances the holy Scriptures ſpeak; and thus even Philoſophers themſelves ſpeak. Yea, the *Copernicans* themſelves, although they profeſſedly own, and defend the contrary; yet in vulgar ſpeaking in our preſent Caſe, ſay, *The Sun riſeth, ſetteth, and moveth*, &c. making that to be the act of the Sun in vulgar Diſcourſe, which they contend to be in reality performed by the Earth. And if Philoſophers, and others ſhould not thus expreſs themſelves according to the appearance of things, and mens vulgar apprehenſions of them, it would need a Comment, and they muſt explain themſelves every time they ſpeak, in order to their being underſtood.

Having given this general Anſwer, I ſhall next conſider the particular Texts themſelves, and ſee whether they neceſſarily infer what they are brought for the Proof of.

And in the firſt place, as for the Texts brought to prove the Immobility of the Earth, it is manifeſt that the *Stability* of the *World*, mentioned in the three firſt Texts, doth not relate to the Earth's motion, either Annual or Diurnal, but to the Condition, State and Order of the World inhabiting the Earth, particularly the Peace and Proſperity thereof. One of our own lateſt, and moſt learned Commentators, the late Biſhop *Patrick* (*e*) underſtands the Goſpel-ſtate to be meant in the firſt and third of the Texts. And his Paraphraſe on that in *Pſal.* 93. 1. is, *He who made the World, will ſupport that excellent Order wherein we are ſettled*; *ſo that it ſhall not be in the power of Man to diſturb what he hath eſtabliſhed.*

(*e*) See his *Commentary on Chron.* and his *Paraphraſe on Pſalms.*

As for what is ſaid in *Pſal.* 104. 5. it is manifeſt that the *Pſalmiſt* is there celebrating the Works of Creation and that there was as fair an occaſion of ſpeaking of the Earth's Reſt, in Relation to its two Motions, as any where. But yet even here alſo the ſecurity and permanency of its State is the thing aimed at. The laſt moſt learned Commentator thus paraphraſes on the place (*f*), *Who hath ſettled the maſſy Globe of the Earth, even in the liquid Air, upon ſuch firm foundations, that none of thoſe Storms and Tempeſts, which beat upon it from without, nor any Commotions from within, can ever ſtir it out of the place he hath fixed for it.*

As for the two remaining places in *Eccleſ.* and *Pſal.* 119. it is plain enough that their Deſign is to ſhew

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(*f*) Biſhop *Patrick's Paraph. on Pſal.* 104. 5.

the Vanity and Inſtability of the things of this World, that they are all more fleeting and uncertain than other matters, even than the Earth it ſelf, on which they have their reſidence. In *Eccleſ.* the wiſe man (who had undertaken to prove all things here below to be Vanity) begins with the State of Man himſelf, and ſhews that to be more fickle and tranſitory than the Earth, on which the various Generations of Men live, and to which their Bodies do all return again. The *Generations* of men paſs away; *but the Earth abideth for ever*, in the ſame unalterable condition, without ſuch going and coming, as that of the Generations of men have.

In *Pſal.* 119. 90. the *Pſalmiſt* celebrates *God's Faithfulneſs* to all the various and ſucceeding Generations of the World, which he ſhews to be as conſtant and unalterable as the

Earth it ſelf, which GOD hath ſo eſtabliſhed, that it abideth through all the ſeveral Generations of Men, when they at the ſame time are fleeting and changing.

Thus it appears that all thoſe ſeveral Texts which aſſert the *Stability of the World*, or *Earth*, prove nothing againſt the *Earth*'s Motion in a Philoſophical Senſe; only expreſs ſome Moral, Theological Truths.

And ſo the ſame may be ſaid of thoſe other places of Scripture, which mention the Motion of the Sun and other Heavenly Bodies, that ſay they riſe, ſet, and perform the Motions which the *Copernicans* aſcribe to the Earth. If we ſhould take theſe Expreſſions in a philoſophical, ſtrict, literal Senſe, and not as vulgar Expreſſions, ariſing from the appearance of things; we ſhall find that very odd and unreaſonable Concluſions may as well be collected from thoſe Scriptures, as the Sun's Motion: as that the Sun hath animal Life, Motion, and Deſire, being ſaid to act theſe things it ſelf, to riſe, to ſet, yea to *haſte to the place* of his Riſing, or as the *Hebrew* hath it, to *pant after*, or *eagerly to deſire* it (*g*). So in *Pſal.* 19. the elegant *Pſalmiſt* giving a poetical deſcription of this noble and admirable work of GOD, the *Sun*, ſaith, GOD hath, in the Heavens, *made a Tabernacle for him*; as if the Sun had an Houſe, a Reſting Place provided for him; from which he comes daily forth with beauty and luſtre, as reſplendent as that of a Bridegroom, and with the ſame ardency, joy and diligence runs his Courſe, as a Champion doth his Race. And laſtly, his

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(*g*) שאפ Anhelavit, inhiavit, vid. *Buxtorf.* Lexicon.

Going forth is ſaid to be *from the end of the Heaven, and his Circuit* to reach *to the ends thereof*; as though the Heavens had two Extremities, or was (as the Ancients fanſied the Earth to be) a long large Plane bounded by the Ocean, under which they imagined the Sun betook himſelf, and was thence ſaid *Tingere ſe Oceano*, to *dip himſelf in the Ocean* when he ſet.

And as in theſe places of Scripture the Sun is ſaid to *move*; ſo in the other places he is ſaid to *ſtand ſtill*, and to *go backward.* But we ſhall find that very abſurd concluſions would follow the taking thoſe Texts in a ſtrict literal Senſe. For in *Joſhua* the Sun is ordered to *ſtand ſtill upon* Gibeon, *and the Moon in the valley of* Ajalon. But it would be very abſurd to take this in a literal Senſe, and imagine thoſe two great Luminaries were confined to thoſe two places, otherwiſe than in appearance to the victorious *Iſraelites*. And if ſo conſiderable a part of the tranſaction be ſpoken according to its appearance, why not the whole? Why might not this Station as well be an arreſt of the Earth's Motion as of that of the Heavens, if the whole Miracle was not (as ſome not improbably think) effected by means of ſome preternatural Refractions, or extraordinary Meteors, *&c.*

And ſo for the Receſs of the Sun, or its Shadow in *Hezekiah*'s caſe, that which in appearance ſeemed to be the action of the Sun is by divers learned men thought to have been the effect of ſuch like extraordinary Refractions or Meteors, as I mentioned in the laſt caſe: or if it was a real Receſs, why not of the Earth, rather than the Sun and whole Heavens?

Thus having anſwer'd the particular Texts, it doth not appear that the Scriptures oppoſe the *Copernican Syſteme*, but that thoſe paſſages which ſeem to do ſo, are ſpoken more according as things appear than as really they are. For as St. *Hierom* ſaith, (*h*), *Conſuetudinis Scripturarum eſt*——*It is the cuſtom of the Scriptures, for the Hiſtorian ſo to relate the opinion men had of many matters, as at that time thoſe matters were by all people taken to be.* And in another place (*i*) *There are many things in the Holy Scriptures, which are ſpoken according to the opinion of the time in which they were done, and not according to their Reality.* And this is no other than what is very reaſonable, and ſuitable to the end and deſign of the Holy Scriptures, which

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(*h*) *Hieron. in Matth.* c. 13.
(*i*) In *Jerem.* 28.

as I have ſaid, is rather to inſtruct men in *Divine and Moral Doctrines*, than *Philoſophical Truths*. And agreeably hereto St. *Auguſtine* anſwers this very doubt concerning the Motion of the Heavens (*i*). *Some of the Brethren* (ſaith he) *move a Queſtion, whether the Heavens ſtand ſtill or are moved, becauſe, ſay they, if they are moved, how is it a Firmament? and if they ſtand ſtill, how do the Stars, which are believed to be fixt in them, revolve from Eaſt to Weſt, the Northern Stars deſcribing leſſer Circles near the Pole?——To which*, ſaith he, *I anſwer, That theſe things do greatly require ſeveral ſubtile and laborious Reaſons, to diſcover truly whether the matter be ſo, or not ſo. For the entering upon, and diſcuſſing of which, I have neither time, neither is it fit*

(*i*) Auguſt. de Geneſi ad Literam. L. 2. c. 10.

it ſhould be done to ſuch as we deſire to inſtruct in the way of Salvation, for the neceſſary benefit of the holy Church.

Having thus anſwered the Objections from Scripture, I ſhall in the laſt place conſider thoſe brought from Senſe and Philoſophy.

The Objection from *Senſe* is, That we ſee the Heavenly Bodies actually to move, and therefore ought to believe they do ſo. But there is no weight at all in this, becauſe whether we our ſelves, or the Object moveth, it amounts to the ſame. As is manifeſt to any one carried in a Boat or Chariot; the Progreſſive motion of which, produceth the appearance of a Regreſſive motion in the unmoved Objects we look upon; according to *Virgil*'s deſcription of *Æneas* and his company's leaving their Port.

(*k*) *Provehimur portu, terræque urbeſque recedunt.*

i. e. *Both Land and Towns receded when we left our Port.* As for the reaſon hereof, I ſhall refer to the Opticians, particularly the famous *Kepler*, who in his *Optices Aſtronom.* hath deſignedly handled this Point.

The Objections from *Philoſophy* are too numerous to be diſtinctly anſwered, eſpecially ſuch as ſeem very frivolous, particularly thoſe grounded on a ſuppoſition of the Verity of the *Ariſtotelian* Philoſophy, as the Immutability and Incorruptibility of the Heavens, *&c.* For anſwers to which I ſhall refer the Reader to *Galilæo*'s *Syſtem Mund.* But for ſuch Objections as ſeem to have ſome reaſon in them, they are chiefly theſe, That if the Earth be moved

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(*k*) Æneid. L. 3. ver. 72.

from W. to E. a Bullet ſhot Weſtward would have a farther Range, than one ſhot Eaſtward; or if ſhot N. or S. it would miſs the mark; or if perpendicularly upright, it would drop to the Weſtward of the Gun. That a Weight dropp'd from the top of a Tower would not fall down juſt at the bottom of the Tower, as we ſee it doth. That Birds flying towards the E. would be hindered in their Flight, but forwarded in flying the contrary way; with much more to the ſame purpoſe. But not to enter into a Detail of Anſwers that might be given to the preceding Objections from the Laws of Motion, and the Rules of Mechanicks and Mathematicks; I ſhall only make uſe of the moſt ingenious *Galilæo*'s plain Experiment, which anſwereth all or moſt of the Objections (*l*). *Shut,* ſaith he, *your ſelf up with your friend*

(*l*) *Syſtem. Mund. Dial.* 2.

in the great Cabin of a Ship, together with a parcel of Gnats and Flies, and other little winged Creatures. Procure alſo a great tub of Water, and put Fiſhes therein. Hang alſo a Bottle of Water up, to empty it ſelf drop by drop into another ſuch Bottle placed underneath with a narrow neck. Whilſt the Ship lies ſtill, diligently obſerve how thoſe little winged Creatures fly with the like ſwiftneſs towards every part of the Cabin; how the Fiſhes ſwim indifferently towards all ſides; and how the deſcending Drops all fall into the Bottle underneath. And if you throw any thing to your Friend, you need uſe no more force one way than another, provided the Diſtances be equal. And if you leap, you will reach as far one way as the other. Having obſerved theſe particulars whilſt the Ship lies ſtill, make the Ship to ſail with what Velocity you pleaſe, and ſo long as the

Motion is uniform, not fluctuating this way and that way, you ſhall not perceive there is any alteration in the aforeſaid effects; neither can you from them conclude whether the Ship moveth or ſtandeth ſtill. But in leaping you ſhall reach as far on the Floor as you did before; nor by reaſon of the Ships motion, ſhall you make a longer Leap towards the Poop than the Prow, notwithſtanding that whilſt you were up in the air, the Floor under your feet had run the contrary way to your Leap. And if you caſt any thing to your Companion, you need uſe no more ſtrength to make it reach him, if he ſhould be towards the Prow, and you towards the Poop, than if you ſtood in a contrary poſition. The Drops ſhall all fall into the lower Bottle, and not one towards the Poop, although the Ship ſhall have run many feet, whilſt the Drop was in the Air. The Fiſhes in the Water ſhall have *no more trouble in ſwimming towards the forepart of the Tub, than towards the hinder part, but ſhall make towards the Bait with equal Swiftneſs, on any ſide of the Tub. And laſtly the Gnats and Flies ſhall continue their flight indifferently towards all parts, and never be driven together towards the ſide of the Cabin next the Prow, as if wearied with following the ſwift motion of the Ship. And if by burning a few grains of Incenſe, you make a little Smoak, you ſhall perceive it to aſcend on high, and hang like a Cloud, moving indifferently this way and that, without any inclination to one ſide more than another. The cauſe of which correſpondence of the Effects, is, that the Ship's motion is common to all things contained in it, and to the Air alſo: I mean when thoſe things are ſhut up in the Cabin: but when they are above Deck in the open Air, and not obliged to follow the*

the Ship's courſe, differences more or leſs may ariſe among the forenamed Effects.

Thus *Galilæo* by this one Obſervation hath anſwered the moſt conſiderable Objections deduced from Philoſophy againſt the Motion of the Earth. And thus much ſhall ſuffice for the Explication and Proof of the *Copernican Syſteme*; eſpecially that part of it relating to the *Solar Syſteme.* Which things I have more largely than ordinary inſiſted on, for the ſatisfaction of many that I am ſenſible doubt of them, and particularly ſome of my Friends (and thoſe not unlearned too) who may be apt to read my following Book with prejudice whereſoever I favour the *Copernican* Notions.

Of the New Syſteme.

And now I paſs from the Second Syſteme to the Third, which is called the *New Syſteme*, and by ſome the *True Syſteme*; which extends the Univerſe to a far more immenſe compaſs, than any of the other Syſtemes do, even to an indefinite Space; and repleniſhes it with a far more grand Retinue than ever was before aſcribed unto it.

This *New Syſteme* is the ſame with the *Copernican*, as to the Syſteme of the Sun and its Planets; as may be ſeen by the Scheme of it in Fig. 3. But then, whereas the *Copernican* Hypotheſis ſuppoſeth the Firmament of the Fixt Stars to be the Bounds of the Univerſe, and to be placed at equal Diſtance from its Center the Sun; the *New Syſteme* ſuppoſeth there are many other Syſtemes of *Suns* and *Planets*, beſides that in which we have our reſidence: namely, that every Fixt Star is a Sun, and encompaſſed with a Syſteme of Planets, both Primary and Secondary, as well as ours.

Theſe ſeveral Syſtemes of the Fixt Stars, as they are at a great and ſufficient Diſtance from the Sun and us; ſo they are imagined to be at as due and regular Diſtances from one another By which means it is, that thoſe multitudes of Fixt Stars appear to us of different Magnitudes, the neareſt to us large; thoſe farther and farther, leſs and leſs.

Of thoſe Syſtemes of the Fixt Stars I have given a rude repreſentation in Fig. 3. together with that of the Sun; which may ſerve to give an unskilful Reader ſome conception of the ſtate of the Univerſe; although there be but little likeneſs in it, for want of room to lay out all the ſeveral Syſtemes in due proportion; which is neceſſary to a true repreſentation of the matter.

In this 3d Fig. the Fixt Stars with their Syſtemes (repreſented by little Circles, about thoſe Stars, which

Circles ſignify the Orbits of their reſpective Planets) are placed without the limits of the Solar Syſteme, and the Solar Syſteme is ſet in the Center of the Univerſe, and figured as a more grand and magnificent part thereof. And ſo it may be looked upon by us, by reaſon of its proximity and relation to us. But whether it be really ſo, whether it be in the Center of the Univerſe, and whether among all the noble Train of Fixt Stars, there be no Syſteme exceeding ours in its magnificent Retinue of Planets, both Primary and Secondary, and other admirable Contrivances, is a difficulty, as out of the reach of our Glaſſes, ſo conſequently above our ability to fathom, although not at all improbable. But be the various Syſtemes of the Univerſe as they will as to their Dignity, it is ſufficient that in all probability there are many of them, even as many as there are Fixt Stars, which are without number.

This *Syſteme* of the *Univerſe*, as it is phyſically demonſtrable, ſo is what, for the moſt part, I have followed in the enſuing Book, but not ſo rigorouſly and obſtinately, as utterly to exclude or oppugn any other Syſteme; becauſe as the *Works of GOD* are truly great, and ſufficiently manifeſt their excellence and magnificence in any Syſteme; ſo I was willing to ſhew the ſame in ſuch Syſtemes as I had occaſion to ſpeak of them in; becauſe I would not offend, and conſequently not bar the force of my arguments upon ſuch Readers, as might happen to be wedded to the *Ariſtotelian Principles*, or prejudiced to the *Ptolemaick*, or any other *Syſteme*: Not that I had my ſelf any doubts about this *New Syſteme*, but think it to be far the moſt rational and probable of any, for theſe reaſons:

1. Becauſe it is far the moſt magnificent of any; and worthy of an infinite CREATOR: whoſe *Power* and *Wiſdom* as they are without bounds and meaſure, ſo may in all probability exert themſelves in the Creation of many Syſtemes, as well as one. And as Myriads of Syſtemes are more for the *Glory* of GOD, and more demonſtrate his *Attributes* than one; ſo it is no leſs probable than poſſible, there may be many beſides this which we have the Privilege of living in. But it is very highly probable the matter is ſo, by reaſon,

2. We ſee it is really ſo, as far as it is poſſible it can be diſcerned by us, at ſuch immenſe Diſtances as thoſe Syſtemes of the Fixt Stars are from us. Our Glaſſes are indeed too

weak ſo to reach thoſe Syſtemes, as to give us any aſſurance of our ſeeing the Planets themſelves, that encompaſs any of the Fixt Stars. We cannot ſay we ſee them actually moving round their reſpective Suns or Stars. But this we can diſcern, *viz.* That the Fixt Stars have the Nature of Suns, as I have made probable in Book 2. Chap. 2. As alſo that there are ſome things very like unto Planets, which ſometimes appear and diſappear in the regions of the Fixt Stars; as I have ſhewn in my diſcourſe of *New Stars*, Book 2. Chap. 3.

But beſides what I have ſaid there, I have this farther to add from ſome late obſervations I have made ſince my writing that part of my Book; and that is, That the *Galaxy* being well known to be the fertile place of *New Stars*, the region in which they commonly appear, I am much inclined to be of opinion, that the *Whiteneſs*

neſs there, is not cauſed by the bare Light of the great number of Fixt Stars in that place, as hath commonly been thought, but partly by their Light, and partly (if not chiefly) by the Reflexions of their Planets; which ſtop and reflect, intermix and blend the Light of their reſpective Stars or Suns, and ſo cauſe that Whiteneſs the *Galaxy* preſents us with; which hath rather the colour of the reflected Light of our Moon than the Primary Light of our Sun.

And that there are Planets enough for this purpoſe, I ſuſpect becauſe I have ſome reaſons to imagine that there are many more *New Stars* in the *Milky-way* (all which I take to be a kind of Planetary Globes) than have ever yet been taken notice of, and that many of thoſe prodigious numbers of Teleſcopial Stars viſible there, are of the numbers of *New Stars* or *Planets*, and not of

Fixt Stars only. This Suſpicion I have for ſome time had, but eſpecially lately from my Views of the *New Star* that now begins to diſappear in the *Swan's Neck.* Which gave me occaſion to inſpect ſome other parts of that Conſtellation, moſt parts of which are well repleniſhed with a numerous train of ſmall Stars. Amongſt which, ſometimes methoughts more have preſented themſelves through one and the ſame Glaſs, and ſometimes I have miſt ſome I thought I before ſaw: and ſometimes alſo methoughts I have ſeen them nearer to, and ſometimes farther off thoſe Stars that did conſtantly preſent themſelves. But as theſe things are to my ſelf novel, and what I confeſs I have rather Suſpicions of than Certainty, I ſhall refer them to the future Obſervations of my ſelf, and others, for their Confirmation; eſpecially becauſe thoſe

Approximations and Receſſes of ſome of the little Stars I ſpake of ſuit not with the Obſervations of ſome very eminent Aſtronomers.

Theſe Obſervations as they will open to us a new, and admirable Scene of the Heavens (if it be as I imagine) ſo I earneſtly recommended the Enquiry into it to ſuch as delight in thoſe matters. For the doing of which, I conceive it may be ſufficient, and the eaſieſt courſe to make the Obſervations in ſome one part of the Milky-way, as in ſome part of the *Swan* for inſtance; and I would adviſe that an Area of the Heavens may be taken in, continuing as much or a little more than falleth within the compaſs of the Teleſcope you make uſe of: Which was the way I practiſed, and that part of the Heavens, in which I obſerved. All the Stars that fall within this Area, an exact Map muſt be taken of, which will ſhew when any Variations happen. And for taking in the larger Area of the Heavens, a Glaſs of 6 or 8 Feet is ſufficient, and rather better for the purpoſe than longer Glaſſes, which take in leſs, and are more troubleſome in uſing.

Having thus repreſented the State of the *Univerſe* according to the *New Syſteme* of it, the uſual Queſtion is, what is the uſe of ſo many Planets as we ſee about the Sun, and ſo many as are imagined to be about the Fixt Stars? To which the anſwer is, That they are *Worlds*, or Places of *Habitation*, which is concluded from their being *habitable*, and well provided for Habitation. This is pretty manifeſt in our Solar Planets, from their being opake Bodies as our Earth is, conſiſting in all probability of Land and Waters, Hills and Vallies, having Atmoſpheres about them, Moons miniſtring unto them, and being enlightned, warmed and influenced by the Sun; whoſe yearly Viſits they receive, for Seaſons; and frequent Returns or Revolutions, for Days and Nights. All which particulars are fully treated of in the following Book, and need not therefore to be anticipated here. Only there is one thing, which for want of ſufficient Obſervations, I could not ſo fully ſpeak of as I would; and that is concerning the *Seas in the Moon*, in Book 5. Ch. 4. Note *a.* whoſe very exiſtence Mr. *Huygens* (*m*) denies, ſaying, *Marium verò ſimilitudinem illic nullam reperio*, &c. i. e. In the Moon *I find no likeneſs of Seas, although* Kepler *and moſt others are of a different opinion. For thoſe vaſt plane Regions, which are much darker than the mountainous parts, and are commonly taken for Seas, and bear*

(*m*) Coſmotheoros, p. 114.

the names of Oceans; in thoſe very places viewed with a long Teleſcope, I find little round Cavities with ſhadows falling within them; which cannot agree with the Surface of the Sea: as alſo thoſe very large Fields when carefully viewed, do not preſent us with a Superficies altogether equal. Wherefore theſe cannot be Seas, but are ſuch places as conſiſt of a leſs bright matter than that which is in the more hilly parts, but in which alſo there are ſome places brighter than others. Thus the moſt ingenious Mr. *Huygens*, who then proceeds to ſhew that there are neither Rivers, Clouds, Air, or Vapours.

But that there are Seas or great Collections of Water, and conſequently Rivers, Clouds, Air and Vapours in the Moon, I ſhall make out from ſome of my own Views and Obſervations; many of which were made with Mr. *Huygens*'s own long Glaſs before mentioned: through which, and all other long Glaſſes, inſtead of imagining the Lunar Spots to be unlike Seas, I have always thought them to look more like Seas, than through ſhort Glaſſes.

It is true indeed that in thoſe Spots we take to be the Seas, there are ſuch Cavities as Mr. *Huygens* ſpeaks of, or rather Mountains with ſhaded Cavities in them, as alſo ſome parts leſs dark than others. Thus in the Southerly Parts of the *Lunar Euxine* and *Mediterranean*, in the *Sinus Sirbonis*, the *Ægyptian*, and divers other Seas, there are ſeveral ſuch Parts that appear more luminous than others, ſome having the appearance of Rocks and Iſlands, ſome of large Shallows, particularly towards the Shores, and eſpecially in the Seas bordering on the Continents, ſuch as the great Southern Continent of the *Lunar Ægypt* and *Palæſtine*. But this is no concluſive argument of thoſe parts not being Seas; becauſe they may be Seas having many Iſlands and Shallows in them. But then in other Parts, and even in ſome Parts of theſe laſt named, the Spots appear darker, and with but few of thoſe Eminences or Iſlands, thoſe brighter or ſhallow Parts. Thus the Northerly *Euxine* and *Mediterranean*, the *Palus Mæotis*, and many other of thoſe Lunar Seas; few of thoſe parts that have the aſpect of Iſlands or Shallows are to be diſcerned in them, only one here, and another there, at conſiderable diſtances from one another.

And in this very manner I doubt not our terraqueous Globe would appear, if viewed at the Moon, or at ſome miles aloft. We ſhould there perceive our deep Oceans would be of a darker colour, like the darker ſpots of the Moon; and the ſingle Iſles of St. *Helena* and *Aſcenſion*, and the more numerous ones of *Ladrones*, *Canaries*, *Azores*, &c. to have the ſame appearance that the few ſcatter'd Iſlands have in the deeper Lunar Seas: and our ſhallow Seas with their numerous Rocks and Iſlands diſperſed about them, eſpecially towards the Continents, would look as thoſe in the Moon do.

That a Reader unacquainted with the Geography of the Moon, may apprehend what I have ſaid here and elſewhere, concerning the parts and appearances of the Moon, I have repreſented them in Fig. 10. and 11. In Fig. 10. the Face of the Full Moon is repreſented, its bright and dark parts with moſt of the Names given them by *Hevelius*, whoſe Lunar Geography is juſtly the moſt followed. In Fig. 11. I have repreſented the appearance of the Moon's Edge on this laſt *Nov.* 4. 1714. ſoon after the Quadrature, for the explication of what is ſaid concerning the Evenneſs of the Surface of the Lunar Spots in B. 5. Ch. 4. Note *a.* It may be there obſerved that the ſurfaces of all the Seas appear ſtrait and level, only the top of here and there a Rock or Iſland preſents it ſelf at a ſmall diſtance. Thus the ſurface of the *Hyperborean* Sea between *a* and *b* appears even and level, although through a Teleſcope that Sea looks but like a great Lake or Marſh. So do the parts of the *Mediterranean* about *d.* from *h* to *i*, except when they are interrupted by Rocks or Land, as they are at *h*, *g b*, and *c.* At the laſt of which places, begins a ridge of Hills encompaſſing the Northern part of the *Mediterranean*, which makes a pretty ſhew in the Teleſcope.

And now conſidering how accompliſhed the Moon, and all the other Planets are for Habitation, how ſolemn an Apparatus is in them for this ſervice: and conſidering alſo that theſe Accoutrements relate to their reſpective Planets only, and in all probability are of little or no uſe to our Earth; with great reaſon therefore the Maintainers of the new Syſteme conclude thoſe Planets, yea all the Planets of the Sun and of the Fixt Stars alſo, to be *habitable Worlds*; places, as accommodated for Habitation, ſo ſtocked with proper Inhabitants.

But now the next Queſtion commonly put is, What Creatures are they inhabited with? But this is a difficulty not to be reſolved without a Revelation, or far better Inſtruments than the World hath hitherto been acquainted with. But if the Reader ſhould have a mind to amuſe himſelf with probable Gueſſes about the Furniture of the Planets of our Solar Syſteme, what Countries 'tis probable are there, what Vegetables are produced, what Minerals and Metals are afforded, what Animals live there, what Parts, Faculties and Endowments they have, with much more to the ſame purpoſe; he may find a pleaſant entertainment enough in the great Mr. *Chriſtian Huygens's Coſmotheoros* and ſome other Authors that have written on the Subject. To which I ſhall refer him, rather than give either him or my ſelf any farther trouble about theſe matters, which are merely conjectural.

Thus having, for the ſake of the unskilful Reader, given an account of the three *Syſtemes* principally concerned in the following Book, and having alſo, for the ſake of the Doubting Reader, inſiſted more largely than ordinary upon the two laſt of thoſe Syſtemes, little remaineth for the putting an end to this long Preface, but to make my Excuſe (if it needs any)

any) for aſſigning the Diameters and Diſtances of the Heavenly Bodies in Engliſh Miles, rather than other larger Meaſures, which would perhaps have come nearer the truth. But this was alſo for the ſake of ſuch as are not very converſant in Aſtronomical Matters and Dimenſions, who can better underſtand you, when you ſay, It is ſo many Miles, than ſo many Degrees, Minutes, or Seconds, or Semidiameters of the Earth, or the other Planets.

And now for a Concluſion, I ſhall only intreat all my Readers to join with me in their earneſt Prayers, that as this Work is deſigned for the good of Mankind, particularly for the Conviction of Infidels and Irreligious, for the Promotion of the Fear and Honour of GOD, and the cultivating of true Religion, ſo it may have its deſired Effect.

W. DERHAM.

THE CONTENTS

Of the following BOOKS.

THE Introduction. Page 1
The Opinion of all Nations about a Deity. 2, &c.
The Diviſion of the Work. 6

Book I. The Magnitude of the Univerſe.

Chap. I. *The ancient and modern reckonings.* 7
Chap. II. *The Magnitude of the heavenly Bodies.* 9
Of the Earth. 10
Of the other Planets. 12
Chap. III. *The Immenſity of the Heavens.* 15
Their extent according to Ptolemy. ibid.

According

According to the Moderns. Page 16, 21
Diſtances and Sizes of the Fixt Stars. 21
Chap. IV. *Practical Reflexions.* 25
Seneca's. 26, &c.

* * *

Book II. Number of the Heavenly Bodies.

Chap. I. *The Numbers of the Heavenly Bodies in general.* 30
Of the Milky-way. 32
Chap. II. *The Fixt Stars are Suns,* &c. 33
What their Uſes. 35
Sun a Fixt Star. 37
Chap. III. *Of New Stars.* 41
Reaſons why Catalogues were made of the Fixt Stars. 42
In what Parts they appear. 44
What they are. 45
The Author's Opinion. 46

* * *

Book III. The due Situation of the Heavenly Bodies.

Chap. I. *The due as well as great Diſtance of them.* 51
Chap. II. *None of the Globes interfere.* 53

Nor their Influences. Page 55
Chap. III. *Nice Proportion of the Diſtances of the Heavenly Bodies.* 57
Not obſervable among the Fixt Stars. ibid.
Of the Solar Syſteme. 59
Cicero'*s Reflexion.* 62

* * *

Book IV. The Motions of the Heavens. 64

Chap. I. *This is a Demonſtration of God.* ibid.
Lactantius'*s Reflexion.* 65
A firſt Mover. 66
Motion of the Fixt Stars. 69
New Stars. 70
Chap. II. *Regularity of the Motions of every Globe.* 72
Their Directions and Planes not caſual. ibid.
Tully'*s Argument.* 74
Chap. III. *The Diurnal Motions.* 76
In what Globes viſible. 77
Solar Spots. ibid.
Jupiter'*s Spots.* 82
Thoſe of Mars, &c. 83
Earth revolves, not the Heavens. 85
Great uſe thereof. 86
Chap. IV. *Periods of the Primary Planets.* 89

Propor-

CONTENTS.

Proportion thereof to their Diſtances. Page 91
Motion in different Paths. 92
Cauſes of Winter and Summer. 93
Sun's Diameter. 95
Chap. V. *Periods of the Secondary Planets.* 97
Uſe of their Latitudes. 98
Mr. Molineux's *Reflexion.* 101
Chap. VI. *Conſtancy and Regularity of the Celeſtial Motions.* 103
Poſidonius's *Sphere.* 104
Tully's *Argument.* 107

⁂

Book V. Of the Figure of the Heavenly Bodies. 111

Chap. I. *Conſonancy of all the Heavenly Bodies in a Spherical Figure.* ibid.
Of the Stars, &c. 112
Of the Earth. 114
Chap. II. *The Hills and Vallies in the Earth and Moon.* 115
Hills in the Earth. 117
Lunar Mountains. 120
How to meaſure them. ibid.
None on the Moon's Limb. 121
Chap. III. *Uniformity of the Globes argue them the Work of God, not Chance.* 124
Cauſes of their Figures enquired into. 126

Chap.

Chap. IV. *Parts of the Globes are well diſpoſed.* Page 127
In the Moon. 128
Jupiter's *Belts.* 130
Mars *and* Venus's *Phaſes.* 132
Parts of the Earth well laid. 133
Waters ſo alſo. 134
Chap. V. *Spherical Figure an Argument of God's Work.* 137
As being moſt convenient for the Land and Waters. 138
For the other Planets. 139

* * *

Book VI. Of Attraction or Gravity.

Chap. I. *Its uſefulneſs in preſerving the Figure of all the Globes.* 141
Chap. II. *The Guard Gravity againſt the whirling round of the Globes.* 147
Of our own. 148
Of the Sun. 149
Of Jupiter. 150
Chap. III. *Gravity retains the Planets in their Orbits.* 153
The Nature and Properties of Gravity. 154
Cauſe of Gravity not aſſigned. 156
The Adjuſtment of Velocity and Gravity. 159

The Motion and Orbs of the Comets. Page 156
The uſe thereof. 161

Book VII. Of Light and Heat. 166

Chap. I. *The Light and Heat of the Sun and Fixt Stars.* ibid.
The degree of the Sun's heat. 168
Of Burning Glaſſes. 169
Chap. II. *The due Poſition and Diſtance of the Sun and its Planets.* 171
Sun the Fountain of Light and Heat. ibid.
Creator's *care manifeſt in the poſition of the Earth.* 173
The Benefits thereof. 175
The Poſition and Diſtance of the other Planets. 177
Chap. III. *Of the neceſſity of Light, and of the Atmoſphere.* 179
To the Earth. ibid.
Of Twilight. 182
Chap. IV. *Of the Moon, and the Returns one Planet makes another.* 183
The Tides. 184
Eclipſes. 186
Lunar Latitude. 188
The Earth a Moon to the Moon. 189
All the Heavenly Bodies uſeful to one another. 192

Chap.

Chap. V. *Of the Secondary Planets in general.* Page 193
What Planets they accompany. 194
Their great uſe in Jupiter *and* Saturn. 195, 196
Chap. VI. *Of* Jupiter*'s Moons, Days and Seaſons.* 197
Its diſtance from the Sun. ibid.
Proviſions for it by frequent Rotations. 198
By the Number of his Moons. ibid.
Things obſervable in thoſe Moons. 199
Chap. VII. *Of* Saturn*'s Moons,* &c. 202
Saturn*'s diſtance.* ibid.
Number of his Moons. 203
Things obſervable in them. 204
Saturn*'s Ring.* 205
Its various appearances. 208
Saturn*'s Diurnal motion.* 211
Chap. VIII. *The Concluſion in behalf of the* Creator *and* Contriver *of all.* 213, &c.

* * *

Book VIII. Practical Inferences from the foregoing Survey. 218

Chap. I. *God's Exiſtence collected from the Heavens by the Heathens.* 219
Ariſtotle*'s Inference.* 220
Tully*'s.* 222

The Conſent of Mankind. Page 224
Seneca's *Opinion.* ibid.
Chap. II. *God's Perfections demonſtrated by his Works.* 227
Chap. III. *God's Relation to us, and our Duty reſulting thence.* 230
The Inferences of Heathens. 231
Chap. IV. Lactantius's *Argument againſt the Divinity of the Heathen Gods.* 235
Some of the Heavenly Bodies, on the contrary, are taken to be Hell. 236
Chap. V. *That we muſt not overvalue the World.* 238
The Dignity of the Planets. 239
Pliny's *Deſcant.* 240
Seneca's. 241
Chap. VI. *That we ſhould aſpire after the Heavenly State.* 243

A SURVEY OF THE HEAVENS.

The INTRODUCTION.

THE *Pſalmiſt* ſaith, (*a*) *The Heavens declare the Glory of* G O D; *and the Firmament ſheweth,* publickly declareth, telleth forth, or preacheth his *Handy Work,* as the Hebrew Word ſignifies

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(*a*) Pſal. 19. 1, 2, 3.

(*a*) *:* that *Day unto Day uttereth Speech, and Night unto Night ſheweth*, or tells forth, *Knowledge.* Which Language of the Heavens is ſo plain, and their Characters ſo legible, that all, even the moſt barbarous Nations, that have no Skill either in Languages or Letters, are able to underſtand, and read what they proclaim. *There is no Speech nor Language where their Voice is not heard: their Line is gone out through all the Earth, and their Words to the End of the World.*

That this Obſervation of the *Pſalmiſt* is agreeable to Experience, is manifeſt from the Deductions which all Nations have made from God's Works, particularly from thoſe of the Heaven's; namely, that there

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(*a*) נגד *ſignificat aliquid verbis efferre, coràm nuntiare, annunciare,* Conrad. Kircher, Concord. Col. 226. Vol. 2. It is derived from נגד *Coràm, Ante.*

is a GOD; and that ſuch as have pretended to Atheiſm, and have deduced God's Works from Chance, *&c.* are ſingular and monſtrous in their Opinions. Thus ſaith *Ælian*, (*a*) *There never was any Barbarian, that contemned the Deity, nor called in queſtion whether there be any Gods or no? or whether they take care of human affairs? No Man, neither* Indian, *nor* Celt, *nor* Ægyptian *ever entertained any ſuch Thought, as* Eumerus, *the* Meſſenian, *or* Dionyſius *the* Phrygian, *or* Hippo, *or* Diagoras, *or* Socias *or* Epicurus. So one of *Plato*'s Arguments for the Proof of a God, is (*b*) *The unanimous Conſent of all, both* Greeks *and* Barbarians, *who confeſs there are Gods.* And *Plutarch* (*c*) agreeable to what our *Pſalmiſt* affirms, tells us whence they

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(*a*) De var. Hiſt. L. 2. cap. 31.
(*b*) De Legibus, L. 10.
(*c*) De Placit. Philoſ. L. 1. c. 6.

collected this Knowledge of a Deity. *Men*, ſaith he, *began to acknowledge a God, when they ſaw the Stars maintain ſo great a Harmony, and the Days and Nights* through all the Year, *both in Summer and Winter to obſerve their ſtated Riſings and Settings.* And to paſs over a great deal of this kind, that I could cite from divers Heathen Authors, *What*, ſaith the *Stoick* in *Tully*, (*a*) *can be ſo plain and clear, as when we behold the Heavens, and view the heavenly Bodies, that* we ſhould conclude *there is ſome Deity of a moſt excellent Mind, by which theſe things are govern'd! —— A Preſent and Almighty God. Which he that doubts of, I do not underſtand*, ſaith he, *why he ſhould not as well doubt whether there be a Sun or no* that ſhines. And then

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(*a*) *Quid enim poteſt eſſe tam apertum, tamque perſpicuum, cùm Cœlum ſuſpeximus, &c.* De Nat. Deor. L. 2. c. 2.

he goes on to prove that this can be no idle Fancy depending on the Caprice of Man, but a well-grounded, ſubſtantial Opinion, bearing the Teſt of ages, and confirmed by the Length of Time. *For*, ſaith he, *Time wears out the Figments of Opinions, but confirms the Judgments of Nature*; or ſuch Notions as are grounded upon the true Judgment and Nature of Things. *For which reaſon*, ſaith he, *both among our ſelves, and in other Nations, the Veneration of the Gods, and the Sacredneſs of Religion augment and improve every Day more and more.*

Thus *the Heavens declare the Glory of God*, even to the Heathen World, ſo manifeſtly are they the Handy-Work of God. And that they are his Work, will appear by taking a View of theſe ſeven Particulars.

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I. The Magnitude of the Heavens.

II. The great Number of the Heavenly Bodies.

III. Their Diſtances.

IV. Their Motions.

V. Their Figures.

VI. Their Gravity.

VII. Their Light and Heat, and the admirable Proviſions made for thoſe Benefits.

BOOK I.

OF THE MAGNITUDE OF THE UNIVERSE, AND THE BODIES therein contained.

CHAP. I.

The Ancient and Modern Reckonings compared.

BEFORE the Invention of the Teleſcope, the Univerſe was thought to be confin'd within far more narrow Bounds, than it is ſince found to be, the fixt Stars being imagined to be all placed in the Starry Heavens (which they called the *Firmament*) at equal Diſtances from the Earth (the Center) like ſo many golden Nails driven in the Top of ſome arched Roof, or other circular Concave, encompaſſing our Eye. Theſe, although far more narrow Bounds, and a more ſcanty Reckoning than it ſhould be, yet was ſufficient to ſhew who was the Maker of ſuch a ſtupendous Arch, and ſo noble a Train as is contained therein.

But according to the modern Reckoning (which is far the moſt rational, and grounded upon better Phænomena) we ſhall find this Branch of the Creation far more magnificent, and worthy of its infinite CREATOR, than thoſe former Computations made it.

And how grand and magnificent a Structure the Heavens are, will appear by a diſtinct Conſideration of the Magnitude of the Heavenly Bodies themſelves; and of the Space in which they are.

* * *

Chap. II.

The Magnitude *of the* heavenly Bodies.

ALthough we are not able to give a certain Determination of the Magnitude of the Heavenly Bodies, by reaſon of their vaſt Diſtances, yet enough we know, and are ſure of, concerning their immenſe Magnitudes, to convince any one that they are the Works of GOD. But to come to particulars.

The Meaſure by which we uſually gage, and compare the Heavenly Bodies, is our Terraqueous Globe; of whoſe Dimenſions and Bulk we can make a pretty good Eſtimate, having tolerably good and accurate Obſervations leading us thereto: the Particulars of which I have had Occaſion elſewhere to ſpecify (*a*).

By theſe Obſervations it appears that the Diameter of this our Globe is above 79 Hundred Miles; that conſequently its Surface is a good deal above 199 Millions of Miles, and its ſolid Content or Bulk near 265 Thouſand Millions of Miles. If there-

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(*a*) *Phyſico-Theol.* B. 2. Ch. 2. In which Place I have made uſe of Mr. *Pickart's* Meaſure of the Earth. But notwithſtanding the Difference be but ſmall, *viz.* a little above 32 Miles in the whole Diameter of our Globe, yet I ſhall make uſe here of our Mr. *Norwood's* and Monſ. *Caſſini's* Meaſures, becauſe they agree to almoſt a Nicety, and Mr. *Caſſini's* were made (by the French King's Command) at greater Diſtances, with the greateſt Accuracy. And according to theſe Meaſures, the Diameter of the Earth is 7967'7 Engliſh Miles, its Surface 199444201 Miles, and its ſolid Content 264856000000 Miles.

therefore we ſhould go no farther from Home than our own Globe, a Maſs we here have worthy of an Infinite Creator, a work proclaiming that great Being that made it.

But as vaſt a Body as this ſeems to be, it is much leſs than many, yea moſt of the Heavenly Bodies that are viſible to us, except two or three of the Planets, which ſeem to be leſs than our Globe, namely *Mars*, whoſe Diameter is reckoned to be but 4875 Engliſh Miles, and the *Moon*, whoſe Diameter is but 2175 Miles; and *Mercury*, whoſe Diameter is 2748 Miles (*a*); but yet theſe are vaſt and amazing Bodies too. But for the reſt; there is good Reaſon to imagine their Bulk exceeds that of our Terraqueous Globe. Thus the two ſuperiour Planets

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(*a*) The Number of Miles which I have here, and all along aſſigned to the Diameters of the ſeveral Planets are the mean Numbers between

Planets by far exceed us; *Saturn* being computed at 93451 Miles in Diameter, and conſequently at 427218300000000 Miles in its Bulk; and *Jupiter* at 130653 Miles in Diameter, and 920011200000000 Miles in Bulk. But yet as amazing Maſſes as theſe all are, yet they are all

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between Mr. *Flamſteed's* in Mr. *Whiſton's Aſtronomical Lectures*, and Mr. *Huygen's* in his *Syſt. Saturn.* and *Coſmotheor.* which (as Mr. *Whiſton* firſt ſuggeſted to me) ſeem to be neareſt the Truth. For whereas the Rays of Light when intercepted by the Edge of a Knife or other Body, are (as Sir *Iſaac Newton* obſerves in his *Princip.* L. 1. Prop. 96.) ſomewhat bent, as if attracted from a ſtrait Line by that Body; and whereas Mr. *Flamſteed's* Meaſures were taken with a Micrometer that pinches, or claſps the oppoſite Edges of a Planet, which would incurvate the Rays one Way; and Mr. *Huygen's* were taken with the Interpoſition of a thin tapering Plate covering the Planet, as far as the Extremity of its Face, which would cauſe an Incurvation of the Rays the contrary way; therefore Mr. *Flamſteed's* Meaſures are as much too little, as Mr. *Huygen's* are too large, and conſequently the Mean between them, probably neareſt the Truth.

far out-done by that ſtupendous Globe of Fire, the *Sun*; which as it is the Fountain of Light and Heat to all the Planets about it, affording them by his benign Rays, and kindly Influence, the great Pleaſures and Comforts of Life; ſo doth it as far ſurpaſs them in its Bulk; its apparent Diameter being computed at 822148 Engliſh Miles, and its ſolid Content at 290971000000000000 Miles, ſuppoſing the Face we ſee of the Sun to be its true and real Globe.

Thus ſtupendous are the Magnitudes of the Globes of this our *Solar Syſteme*. But theſe are not all, nor perhaps the moſt conſiderable Bodies of the Univerſe. For the fixt Stars, although in Appearance, but ſo many golden or flaming Spots, yet are, with great probability, ſuppoſed to be ſo many Suns, ſurrounded with their reſpective Syſtemes of Planets, as our Sun is; and imagined to be no leſs in Magnitude, if not greater, (ſome of them at leaſt) than our Sun is, but only diminiſhed in Appearance, by their prodigious Diſtances from us.

If now we reflect upon the prodigious Maſſes of thoſe many Heavenly Bodies that preſent themſelves to our View (and many more I ſhall ſhew are unſeen) what a ſurprizing Scene do the Heavens afford us of the great CREATOR's Power! A Train of ſuch immenſe Bodies, that what leſs than an Almighty Hand, could firſt find matter ſufficient for, and then compoſe, ſuch Magnificent Works! But yet what is the Magnitude of all theſe Bodies to that immenſe Space in which they are? Which is the next thing to be conſidered.

CHAP.

Chap. III.

Of the IMMENSITY *of the Heavens.*

IT is neceſſary that I ſhould give a diſtinct conſideration to the immenſe Space poſſeſt by the Heavenly Bodies, becauſe it was once imagined to be limited by the narrower Bounds of the *Ptolemaic Syſteme*, by that which they called the 'Απλανής, the *Starry Concameration*, or *Firmament* of the fixt Stars, as I have before intimated; but now with far greater Probability, and Reaſon, it is extended to an indefinitely larger Space, a Space ſufficient, without all doubt, to contain all the noble Variety of Syſtemes therein; not only our own of the Sun, but all thoſe others I mentioned, of the fixt

Stars alſo. But for the better proof, and more eaſy Apprehenſion of the Magnitude of this vaſt expanded Space, let it be conſidered,

1. That ſome, if not every one, of thoſe vaſt Globes of the Univerſe have a Motion. This is, in ſome, manifeſt to our Sight; and may eaſily be concluded of all, from the conſtant Similitude and Conſent that the Works of Nature have with one another. But in what manner theſe Motions are performed, whether by the Motion of the Heavenly Bodies round the Earth, or by the Earth round its own Axis, or any other way, it matters not much now to enquire.

2. It is manifeſt that the Earth is ſet at ſuch a due Diſtance from the Heavenly Bodies, and the Heavenly Bodies at ſuch a due Diſtance from one another, as not to interfere, claſh with, or diſorder one another.

Nay ſo great is their Diſtance, ſo convenient their Situation, that they do not ſo much as eclipſe one another, except ſuch Planets as are called Secondary.

3. It is farther manifeſt alſo, That thoſe vaſt Bodies are ſo far off, as to appear extreamly ſmall to our Eye, conſidering their prodigious Magnitudes.

Now for the effecting of this, or any of the other Matters, it is neceſſary that there be a ſufficient Space. And that there is ſuch, and what that Space is, we may make a Judgment of by conſidering Particulars, according to the beſt Obſervations we have of theſe things.

And to begin neareſt Home; the neareſt of the Heavenly Bodies to us, is the *Moon*; whoſe Orb is the leaſt of any of the Celeſtial Globes, but yet ſhe takes up a Space of near 480 thouſand Engliſh Miles in Breadth (*a*) to perform her monthly Revolution in. And as for the Earth, if with the Moderns we ſuppoſe it, together with its Satellite the Moon, to revolve round the Sun; or (which amounts to the ſame thing) if the Sun revolves round the Earth, this *Magnus Orbis*, as it is uſually called, is a Space of above 540 Millions of Miles Circumference (*b*), or 172 Millions

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(*a*) The Moon's *mean Diſtance* from the Earth, according to Sir *Iſaac Newton*'s *Princip.* p. 430. is 60 ¼ Semidiameters of the Earth, according to which the Diameter of the Moon's Orbit is 479905 Engliſh Miles.

(*b*) Concerning the Diſtance between the Sun and the Earth, there is a great Diſagreement between the former and latter Aſtronomers, occaſion'd by the Diſagreement between their Obſervations of the Sun's *Horizontal Parallax* (which is equal to the Earth's Semidiameter viewed at the Sun) *Tycho* making it 3 minutes, *Kepler* but one, *Bullialdus* 2 minutes, 21 ſeconds, and *Riccioli* but 28 ſeconds. Conſequently the Diſtances ariſing from hence are leſs than thoſe of the latter

Millions of Miles Breadth. And if to that we add the Increment cauſed by the Sweep of the Moon, or the

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latter Aſtronomers. The very ingenious and accurate Monſ. *de la Hire* in his *Tabul. Aſtron.* thinks the Sun's Horizontal Parallax to be not above 6 ſeconds, and his Diſtance therefore to be 34377 Semidiameters of the Earth, or 136952807 Engliſh Miles. But although his Obſervations were made ſince, yet I ſhall make uſe of Monſ. *Caſſini*'s Number, being deduc'd from very ingenious and accurate Obſervations of the Parallax of *Mars*, and agreeing nearly with the Determination of two great Men, Mr. *Flamſteed* and Mr. *Huygens*, and I may add Dr. *Halley* too, who make it about 10 or 12000 Diameters of the Earth. That great Aſtronomer (Monſ. *Caſſini* I mean) aſſigns a Number between them, in his *Les Elemens de L' Aſtron.* §. 37. *That the Sun's Parallax being ſuppoſed to be 9½ Seconds, gives the Diſtance of the Sun from the Earth 21600 Semidiameters of the Earth:* which are equal to 86051398 Engliſh Miles. And imagining the *Magnus Orbis* to be a Circle (as it is indeed an Ellipſis not much differing from a Circle) the double of that Number is the Length of its Diameter, *viz.* 172102795 Engliſh Miles.

Theſe Numbers are different from thoſe I have aſſigned in my *Phyſico-Theol.* B. I. ch. 4. Note 5. from a Miſtake at that time.

Excurſion of her Orb beyond the *Magnus Orbis*, we ſhall have a Space yet broader by near 280 Thouſand Miles. But as vaſt a Space as this ſeems to be, yet it is not ſuch as to cauſe either the Earth or Moon to claſh with any of the other Celeſtial Globes, as I have ſaid; nay, ſo far from that, that not ſo much as their Shade approaches any of them. In which caſe, what ample Orbs muſt the three Superior Planets have? what a Space is neceſſary for them and their more numerous Moons to perform their much larger Courſes in? And accordingly, ſuch Spaces they and the reſt of the Planets are all found to have: *Saturn* an Orb of 1641526386 Engliſh Miles Diameter; *Jupiter* an Orb of 895134000 Miles; *Mars* of 262282910 Miles; *Venus* of 124487114 Miles; and *Mercury* an Orb of 66621000 Engliſh

liſh Miles (*a*): all of them Spaces ſo accurately laid out, and Diſtances ſo duly proportioned to their Revolutions about the Sun, that abundantly manifeſt infinite Wiſdom to have been concerned in their Appointment, as I intend to ſhew in proper Place.

But now after this Account of this ſo prodigious a Space as that of our *Solar Syſtem* is, what is it to the nearly infinite *Expanſum* occupied by the reſt of the Heavenly Bodies! Of which we may have a faint Adumbration by conſidering the Diſtances which, with the greateſt Probability of Obſervation and Reaſon, are aſſigned to the *Fixt Stars*. In order

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(*a*) Theſe Numbers are deduced from the Diſtance between the Sun and Earth aſſigned in the preceding Note, and Sir *Iſaac Newton*'s Diſtances of the Planets from the Sun computed from their Periods in his *Principia*, L. 3. *Phænom.* 4. and are, as I humbly conceive, much more accurate than other Calculations that I have met with.

to the making an Eſtimate of which Matter, let it be ſuppoſed (which is uſually allowed) that the fixt Stars are ſo many Suns; that they are of the ſame, or nearly the ſame Magnitude as our Sun is; and that the Difference of their Magnitudes ariſeth from the Difference of their Diſtances. If ſo, then it will follow, That the fixt Stars are each of them as much farther from us than the Sun, as their apparent Diameters are leſs than that of the Sun (*a*). And foraſmuch as few of them appear otherwiſe than as Points even through our beſt Teleſcopes, therefore how prodigiouſly farther muſt they needs be from us than the Sun is, to cauſe their Appearance to be ſo very much leſs than the Sun? For an Example, let us take one of the fixt Stars ſuppoſed

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(*a*) Compare the ſagacious Dr. *David Gregory*'s Demonſtration of this in his *Aſtron.* L. 3. Prop. 56, 60, and 61.

to be neareſt to us, as being the brighteſt and largeſt, namely *Syrius.* Now this, by accurate Obſervations (*a*) hath been found to be in Appearance 27664 times leſs than the Sun; and conſequently, by the foregoing Rule, it is ſo many times farther off than the Sun is, which will amount to above 2 Millions of Millions of *Engliſh* Miles. And if ſo, what an immenſurable Space is the Firmament? wherein a great Number of Stars leſſer and leſſer, and conſequently (according to the foregoing Suppoſition) farther and farther off, are ſeen with our naked Eye, and many more diſcovered with our Glaſſes, and ſtill many more and more with better Glaſſes (*b*), and in all probability many

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(*a*) See Mr. *Huygens* in *Coſmotheor.* p. 137.

(*b*) In viewing the Planets with my longer Glaſſes (eſpecially the Planets of a weaker Light) it often falls out that divers of the fixt Stars, and ſome of them very ſmall, preſent themſelves at many others that eſcape the reach of our utmoſt Art to deſcry: which may conſequently be as far diſtant from thoſe we ſee, as thoſe are from us.

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at the ſame time within the Glaſs, notwithſtanding its *Area* is not ſufficient to contain both *Jupiter* and his moſt diſtant *Satellites.* By which means it is ſometimes difficult to diſtinguiſh between thoſe Fix'd Stars and the *Satellites* of the Planets. Thus I have ſometimes been ready to fanſy that I ſaw one or more *Satellites* near *Mars,* until by future Obſervations I perceived they were only ſome of the Teleſcopick fix'd Stars lying in the way of *Mars.* So about *Saturn,* I have often diſcerned the Likeneſs of many *Satellites,* but I am not ſure I ever ſaw above three. From whence it is manifeſt, that in all Parts of the Heavens there are many Stars which preſent themſelves to our Eye through our long Glaſſes, that are otherwiſe inviſible to us.

C H A P.

CHAP. IV.

Practical Deductions from, and Reflexions upon, the MAGNITUDE *of the* Heavens.

HAVING ſet forth the prodigious Magnitude of the Heavenly Space, and of the Bodies therein contained, before we proceed farther, let us pauſe a little, to conſider what Influence theſe Things ought to have upon us.

And in ſhort, who can behold the Regions above, and conſider the Things therein contained, and at the ſame time not own them to *declare the Glory of God?* Who can view that immenſurable Firmament in which thoſe Bodies are, and not acknowledge his Handy-Work? We admire, as juſtly we may, the vaſt Bulk of this our own Globe: but when we conſider how much it is ſurpaſſed by moſt of the Heavenly Bodies, what a Point it degenerates into, and how very little more even it, and what we call its *Great Orb* together alſo, are, when ſeen from the Heavens, this gives us a juſt and noble Idea of the Infinite Creator's Works, ſuch as is worthy of God, and ſuch as may make us ſlight, not overvalue, this little Heap on which we dwell, and cauſe our Thoughts and Deſires to ſoar among the Heavenly Glories. But for an Application of theſe Conſiderations, let us hear *Seneca's* Reflexions upon the Matter (*a*), who on this Account recommends Virtue, not purely *becauſe it is a noble thing in its own Nature, and a great Bleſſing*

(*a*) Nat. Quæſt. L. 1. Præfat.

to be free from Evil, but alſo becauſe it enlargeth the Mind, and prepares it for the Knowledge of Heavenly things, and makes it fit to aſſociate with God (*a*).——*Then,* ſaith he, *the Mind hath the conſummate and full good of our human State, when having conquered all Evil, it ſoars aloft, and wandering among the Stars above, it is able to deride the ſtately Structures of the Wealthy, and all their Riches.*——*Neither,* ſaith he, *can it contemn the Porches and Roofs ſhining with Ivory, the clip'd Groves, and the pleaſant Streams conveyed to their Houſes, until it hath wandered throughout the World, and from above looking down upon this little Globe, covered in a great meaſure by the Sea, and, where not ſo, ſlovenly, and either burnt up in one part,* or *frozen in the other, it then ſaith to it ſelf,*

(*a*) *Qui in conſortium* DEI *veniat.*

Is this that little Point that is divided among ſo many Nations by Fire and Sword? Oh how ridiculous are the Bounds of Mortals! when this River divides this Nation, that Mountain boundeth another, and that Deſart another? For as for this World, ſaith he, *It is a Point in which ye ſail, in which ye war, in which ye diſpoſe of Kingdoms. But above, are vaſt Spaces, into the Poſſeſſion whereof the Mind is admitted, on Condition it hath brought but little of the Body along with it, that it hath cleanſed itſelf from every filthy thing, and being diſengaged from the World, hath made itſelf illuſtrious, by being expeditious and light, and content with little things. When ſuch a Mind,* ſaith he, *hath touched thoſe Celeſtial Regions, it is then nouriſhed and grows; and as if delivered from its Bonds, it returns to its original State. And this Argument it hath of its Divinity, that*

that it delights in divine Matters, and is converſant with them, not as things ſtrange, but its own. There it ſecurely beholds the riſing and ſetting Stars, their different Courſes, &c. There this curious Spectator diſcuſſes every thing, and ſearches out every thing. And indeed what ſhould it do but pry into thoſe Matters, ſince he knows they belong to himſelf? Then he contemns the narrow Bounds of his Habitation in this World.—— And here at laſt he learns what he hath long enquired after: there he begins to know God (*a*).

(*a*) *Illic incipit* DEUM *noſſe.*

BOOK II.

THE *Great NUMBER* OF THE Heavenly Bodies.

CHAP. I.

A General View of the NUMBERS *of the* Heavenly Bodies.

HAVING in the preceding Book given a Demonſtration of God from the *Magnitude* of the Heavenly Bodies, I ſhall do the ſame in this from their *Number*; a Number ſo great, that we cannot view and conſider them without Aſtoniſhment. Were there no more of them than the Sun, and the Planets (both Primary and Secondary) ſuppoſed to move about him, there would be a Number ſufficient to manifeſt an Almighty and Wiſe CREATOR. But when we view the Heavens, and ſee our ſelves ſurrounded with ſo prodigious a Number of illuſtrious Bodies, of various Magnitudes; when we go to other Parts of this our Globe, from the Northern, ſuppoſe, to the Southern Pole, and there diſcover a great Multitude of other Stars that were never ſeen in our Hemiſphere: when we perceive the Heavens thick beſet with them in every Place; and when (as I already hinted) we view the Heavens with our Glaſſes, and diſcover many more than our naked Eye could reach; and when we again view them with better and better Inſtruments, and ſtill diſcover more and more of thoſe Starry Globes; when particularly we ſurvey what they call the *Milky-Way*, and ſee the prodigious Number, I may almoſt ſay Cluſters of Stars, that fill that Region of the Heavens, and cauſe that remarkable Whiteneſs there: I ſay, when we ſee ſuch prodigious Numbers of thoſe Heavenly Bodies, which no Art of Man can number; and when we farther conſider, that in all probability we do not ſee the half, nay perchance not the thouſandth Part of what the Heavens do contain; as we cannot but be ſtruck with Amazement at ſuch a multitude of GOD's glorious Works, ſo we cannot but own the *great CREATOR* in them; and we are worſe than Men, if we do not give him his due Praiſes.

CHAP.

CHAP. II.

That the Fixt Stars *are* Suns *encompaſſed with Syſtemes of* Planets.

ALTHOUGH the Number of the Erratick, and Fixt Heavenly Bodies we ſee, are ſufficient to ſet forth the Exiſtence and Praiſes of their *great* CREATOR, yet there is one thing more that I cannot eaſily paſs over (though it hath only high Probabilities for it) becauſe it gives us a far more noble and agreeable Idea of the Creation, than the World was ever, that we know of, acquainted with before; and that is, That the beſt and moſt learned modern Aſtronomers do generally ſuppoſe the great multitude of Fixt Stars we ſee, or imagine to be in the Univerſe, to be ſo many *Suns*, and each of them encompaſſed with a Syſteme of *Planets* like our Sun.

And that the *Fixt Stars* are *Suns*, or of much the ſame Nature as our Sun, there is great reaſon to conclude,

1. Becauſe they are Bodies no leſs immenſe (as I have ſaid) than the Sun, but only diminiſhed, in appearance, by their prodigious diſtances from us.

2. Becauſe they ſhine by their own native Light, not by any borrowed from the Sun. For ſo great are their diſtances from the Sun, and from us alſo, that it is not poſſible their Light ſhould be received from the Sun, and reflected to us, as that of the Moon and other Planets is. And withal, ſo brisk and vivid is their Light, and ſo very ſmall their apparent Diameters, when diveſted of their glaring Rays, and made to

have their true appearance through our Teleſcopes, that no queſtion is to be made, but that they ſhine by their own innate Light, as our Sun doth.

And if the Fixt Stars are ſo many Suns, certainly they miniſter to ſome grand Uſes in the Univerſe, far above what hath uſually been attributed unto them. And what more probable Uſes, than to perform the Office of ſo many Suns? that is, to enlighten and warm as many Syſtemes of Planets; after the manner as our Sun doth the Erraticks encompaſſing it. And that this is the Uſe and Office of the Fixt Stars is probable,

1. Becauſe this is a far more probable and ſuitable uſe for ſo many Suns, ſo many glorious Bodies, than to ſay they were made only to enlighten and influence our leſſer, and I may ſay inferior, Globe; which another Moon or two, or one or

two of thoſe very Suns ſet nearer to us, would have better done, than all the whole train of Heavenly Bodies now doth. But inſtead of this, many of them, nay perhaps the greateſt number of them, are at ſuch immenſe diſtances (as ſhall be ſhewn under the next Head) that they are out of the reach of our naked eye. In which caſe, what uſe is it likely ſuch great numbers of ſuch immenſe, unſeen, far diſtant Bodies can be to our World, when there are ſo many already of divers Magnitudes of thoſe that fall under View, that (beſides other much greater Uſes they may ſerve unto in the Univerſe) do miniſter to our help, and comfort, here upon Earth, in ſupplying the Abſence of the Sun and Moon by Night?

2. From the Parity, and conſtant Uniformity obſervable in all God's Works, we have great Reaſon to conclude, that every Fixt Star hath

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a Syſteme of Planets, as well as the Sun. For it is certain, that the Sun is a Fixt Star to the Fixt Stars, as they are to the Sun. And in this caſe, if (as the juſtly renowned Mr. *Chriſtian* (*a*) *Huygens* argues) *we ſhould imagine ourſelves to be placed ſomewhere in the Heavenly Regions, as far from the Sun as from the Fixt Stars, we ſhould then perceive no difference between the one or the other. For it would be very unlikely that we ſhould ſee any of the Solar Planets, either by reaſon of the diminiſhing of their Light, or becauſe their Orbs would ſink into the ſame lucid Point with that of the Sun. Being then ſo placed, we ſhould imagine all theſe Stars* [both Sun and Fixt Stars] *to be much of the ſame Nature and Kind; and from a view of any one of them nearer to us than the reſt, we ſhould*

(*a*) Coſmotheoros, *p.* 133.

make our judgment of them all. And now being, ſaith he, *by the favour of God, admitted ſo near one of them, namely the Sun, as to ſee ſix leſſer Globes revolving round about him, and other Secondary ones revolving round ſome of them: why ought we not to have the ſame judgment of the reſt of thoſe Suns, as of this, and think it altogether probable, that this is not the only Star, of all the number, that is encompaſſed with ſuch a train, or in any reſpect excels the reſt? Neither alſo that this Star alone revolves round its own Axis, but rather that all the reſt have ſomewhat of the ſame kind alſo.* And ſo that learned Perſon goes on in the further purſuit of his ingenious Argument.

3. Beſides thoſe ſtrong probabilities, we have this farther to recommend thoſe imaginations to us, that this Account of the Univerſe is far more magnificent, worthy of, and

becoming the infinite CREATOR, than any other of the narrower Schemes. For here we have the Works of the Creation, not confined to the more ſcanty limits of the Orb, or Arch of the Fixt Stars, or even the larger Space of the *Primum Mobile*, (which the ancients fanſied were the utmoſt Bounds of the Univerſe) but they are extended to a far larger, as well as more probable, even an indefinite, Space; as was ſet forth in the firſt Book. Alſo in this Proſpect of the Creation, as the Earth is diſcarded from being the Center of the Univerſe, ſo neither do we make the Uſes and Offices of all the glorious Bodies of the Univerſe to center therein; nay in Man alone, according to the old vulgar Opinion, that *all things were made for Man* (*b*). But in this our Scheme, we have a far more ex-

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(*b*) See *Phyſico-Theol.* B. 2. c. 6. N. 3.

tenſive, grand, and noble View of God's Works: a far greater number of them; not thoſe alone that former ages ſaw, but multitudes of others that the Teleſcope hath diſcovered ſince; and all theſe far more orderly placed, throughout the Heavens, and at more due and agreeable diſtances, and made to ſerve to much more noble and proper ends: for here we have not one Syſteme of Sun and Planets alone, and one only habitable Globe, but myriads of Syſtemes, and more of habitable Worlds (*c*), and ſome, even in our own Solar Syſteme, as well as thoſe of the Fixt Stars. And conſequently if in the Sun and its Planets, altho' viewed only here upon the Earth at a great Diſtance, we find enough to entertain our Eye, to captivate our Underſtanding, to excite

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(*c*) See the Preface, p. 50.

our Admiration and Praiſes of the infinite CREATOR and Contriver of them; what an Augmentation of theſe Glories ſhall we find in great multitudes of them! in all thoſe Syſtemes of the Fixt Stars throughout the Univerſe, that I have ſpoken of, and ſhall have occaſion to mention again in the next Chapter!

CHAP. III.

Of New Stars.

BESIDES the Planets of our Solar Syſteme, and the wonderful number of Fixt Stars, there are ſome others, which are called *New Stars*, which ſometimes appear and diſappear in divers Parts of the Heavens, and will deſerve a place here.

Some of theſe New Stars have been taken notice of as early as *Hipparchus*'s time, who *ſeeing ſuch a New-Star, and doubting whether it often happened, and whether the Stars we take to be Fixt were ſo or no; he* therefore (as (*d*) *Pliny* tells us) *ſet upon numbering the Stars for poſterity; a difficult Task,* he ſaith, *even for a God: and by proper Inſtruments he marſhalled them in ſuch order, that their Places and Magnitudes might be known: by which means it might be eaſily found, not only whether they decayed and periſhed, or were again renewed; but alſo whether any of them changed their places, or had any Motion, as alſo whether they increaſed or decreaſed.* Thus *Pliny.*

Since which time many other ſuch New Stars have been taken No-

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(*d*) Plin. Nat. Hiſt. L. 2. c. 26.

tice of by others. To paſs by the New Stars in *Hadrian*'s, *Valentinian*'s, *Honorius*'s and *Otto*'s times, I ſhall name only ſuch as have been more lately taken notice of by men of good Judgment in theſe matters; ſuch were thoſe New Stars obſerv'd by *Tycho Brahe*, *David Fabricius*, *Janſon*, *Bayer*, *Kepler*, *Marius*, *Byrgius*, *Holwarda*, *Hevelius*, *Montanari*, *Bullialdus*, *Caſſini*, our Mr. *Flamſteed*, and ſome others (*e*); to which may be added a *New Star* that appears at this very time I am writing, in the Neck of the *Swan*; the ſame, in all probability, that hath been ſeen

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(*e*) For a Catalogue of theſe and other New Stars, the Conſtellations in which they appeared, and other Matters relating to them, I ſhall refer to *Riccioli*'s *Almageſt.* Lib. 8. §. 2. cap. 1. *Hevelii Prodrom.* in his Deſcription of the Comet in 1665. p. 433. the *Appendix* to *Mercator's Aſtron.* and Mr. *Lowthorp*'s *Abridg.* Vol. 1. p. 247.

before by Mr. *Kirch*, (*f*) in 1687, and 1688, and perhaps by *Bayer* long before, as alſo *Hevelius* and others.

Of theſe *New Stars*, there is reaſon to imagine there may be many, by reaſon they are not confined to any one part of the Heavens, but appear and diſappear in divers Conſtellations, and divers parts of thoſe Conſtellations, as in *Caſſiopeia*, the *Swan*, the *Great Bear*, *Andromeda*, *Eridanus*, the *Whale*, the *Ship*, and divers other parts of the Heavens.

(*f*) In the *Miſcellanea Berolinenſia*, p. 210. Mr. *Kirch* ſaith, he, for ſome time, ſought this Star in vain, but at laſt on $\frac{6}{16}$ *Auguſt*, 1687. he found it with the help of an 8 Foot Tube, but very ſmall, and that it grew bigger and bigger, ſo as on *October* 23. to be ſeen with the naked Eye, until having arrived to its greateſt Magnitude, it again became leſs and leſs, and at laſt inviſible even in a Teleſcope. By frequent Obſervations he diſcovered its Motion to be very regular, and its Period to be 404½ days.

What theſe *New Stars* are, is hard to determine. *Meteors* they cannot be, becauſe they are of a long continuance, and much too far off, for Bodies that emit ſo little light, as Meteors do, to be ſeen by us. And as for other Opinions about them, they are too many, and too frivolous (ſome of them) to be named (*g*), except one or two of the moſt probable. Among which, one is of ſome Perſons that think, they may be ſuch Stars, as have one ſide darker than the other, (as one of *Saturn*'s *Satellites* is ſuppoſed to have) and ſo appear only when the bright ſide is turned towards us, and diſappear as the darker takes place. Some think they may be Fixt Stars that expire in Light and Vapours (*h*)

(*g*) If the Reader hath a mind to ſee a variety of theſe Opinions, he may find them largely enough handled in *Riccioli*'s *Almageſt. ubi ſuprà*, c. 17.

(*h*) This is what Sir *Iſaac Newton* ſurmiſes in his *Princip. L.* 3. *Prop.* 42.

and are again rekindled, and recruited by the Acceſs of Comets. Others take them to be Comets themſelves. But if I may be admitted to ſpeak what was formerly my own opinion, I rather took them to be *Erraticks* of ſome kind or other; and that for theſe Reaſons:

1. From ſome of them, as I thought, ſeeming to change their Places, and appearing ſometimes farther off, and ſometimes nearer unto other Stars: as I have ſaid in the Preface, *p.* 45.

2. From that Increaſe and Decreaſe of their Light and Magnitudes which is conſtantly obſerved in them; they being at firſt obſcure, and hardly diſcernible, but by degrees growing brighter and brighter, till ſome of them equal the light of *Venus*; and others the light of the Fixt Stars, of the Firſt, Second, and Third Magnitudes: and then again, as gradually

grow leſs and leſs, till they utterly diſappear.

3. From their Periodical motion, and return after a certain time. This indeed hath not been ſo carefully and judiciouſly taken notice of, as it deſerves, or ſo as to bring their Periods under certain determinations; but yet in ſome of *Hevelius's* and *Caſſini's* Obſervations, it hath been diſcovered, that ſome of the ſame Stars have returned, as particularly that in the *Whale's Neck*, and that which now appears in the *Swan's Neck*, which, as I juſt before (*pag.* 44.) ſaid, hath a Period of 404½ days, according to Mr. *Kirch's* obſervations.

Theſe were my reaſons for ſuſpecting thoſe *New Stars* to be *Erraticks*, rather than *Fixt Stars*, either recruited, or having dark and light ſides.

But the grand Difficulty is, what kind of *Erraticks* they are, whether *Wandering Suns*, or *Planets* (like ours) of other Syſtemes? That they ſhould be *Wandering Suns*, is ſomewhat odd to aſſert: and of what uſe they ſhould be, is hard to imagine, ſince there is nothing of this kind in the Univerſe, that we know of, that may aſſiſt our imagination.

And as to the latter opinion, I confeſs I have been much enclined to ſuſpect that they might be Planets revolving round ſuch Suns, as caſt a much fiercer and more vigorous Light than our Sun doth; and that theſe their Planets might be more denſe than ours, and have Surfaces more ſtrongly reflecting light, and perhaps be much larger too. But notwithſtanding that *Planetary Reflected Light* may be ſent to very great diſtances by theſe means, yet without extravagant Suppoſitions of this nature, it may be doubted whether it would reach us, ſo far off as the Fixt Stars are. And beſides this, another doubt is, That altho' there are divers Stars near thoſe New Stars, of greater Magnitudes than any of thoſe New Stars are (which I have had the fortune to ſee) yet I can ſcarce think them big enough, to conclude them to be the Suns about which thoſe New Stars (if Planets) move. And therefore being uncertain what to determine in ſo intricate a matter, I ſhall leave it to future better Obſervations (which the late long dark Weather hath hindered me in the proſecution of) which I hope may afford us ſo good light, as may lead us into a much greater knowledge of thoſe rare Phænomena.

But whatever thoſe New Stars are, they are a farther Demonſtration of GOD's Power and Glory: and that there are many more of the grand Works of the Creation, than what our Eyes behold at all, or that we have only now and then a glimpſe of. But if they are Planets of other Syſtemes, ſome of thoſe Erraticks revolving round ſome of the Fixt Stars, then do they lay open a ſtill more glorious Scene of GOD's Works, and give us ſuch a repreſentation of the ſtate of the Univerſe, that the World never dreamt of before, and that even Angels themſelves may be amazed at the ſight of.

BOOK III.

THE DUE SITUATION OF THE Heavenly Bodies.

CHAP. I.

Of the due as well as great DISTANCE of the Heavenly Bodies.

I HAVE before taken notice of the immenſe Diſtance of the Heavenly Bodies, that it is ſuch as makes thoſe vaſt Bodies the Fixt Stars (no leſs in all probability, as I ſaid, than the Sun it ſelf) to degenerate into ſo many Points, yea to eſcape our eye; nay more than this, that it cauſeth even our own *Great Orb* which our Earth deſcribes about the Sun, to ſink into almoſt a Point, or at leaſt a Circle of but a few Seconds Diameter. I ſhall therefore ſay no more on that matter. But that which I ſhall ſpeak of in this Book, is the due Proportion of the Diſtances of the Heavenly Bodies, that they are not ſet at random, like a Work of Chance, but placed regularly, and in due order, according to the beſt methods of Proportion and Contrivance. Which will be manifeſt from the following Chapters, which will ſhew that the Diſtance is ſuch, that none of the Globes interfere with one another: but inſtead of that, are in due and the moſt nice, commodious Proportion.

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Chap. II.

That none of the GLOBES *of the Univerſe interfere.*

HAD the Univerſe been the Work of Chance, or any thing but of a wiſe Architect, there would have been a great many blunders and inconveniencies in the Situation of ſuch a prodigious number of immenſe Globes, as the Univerſe doth contain. Some would have been too near, ſome too far off, ſome would have met with, knock'd and ſtop'd one the other, and ſome would have ſo interfer'd, as to have incommoded the other, ſome way or other. But inſtead of this, every Globe throughout the whole Creation is, as far as it is poſſible for us to obſerve, ſet at ſuch a due Diſtance, as not only to avoid all violent Concourſes, but alſo ſo as not to eclipſe or ſhade one the other, wherever it may be prejudicial, or indeed not uſeful and convenient, or ſo as to hinder one anothers kindly Influences, or to prejudice one another by noxious ones. This is very manifeſt in our own Syſteme of the Sun; and becauſe we ſee it not otherwiſe, we may conclude it to be ſo in all; unleſs we ſhould make ſome exception for what is ſuſpected (and indeed only ſuſpected) of *Comets*, which in their approaches towards the Earth, are imagined to cauſe Diſeaſes, Famines, and other ſuch like Judgments of God. But this is only Surmiſe, and what befals the world at other times, without the viſible approach of any Comet. But however, ſuppoſing, that as Comets move in Orbs very different from thoſe of the other Heavenly Bodies, ſo their Effects and Influences may be as different ; yet this may be, and no doubt is (becauſe it may be proved) with the concurrence, and by the appointment of the Divine Providence; who, as Governour of the World, might make ſuch noxious Globes to execute his Juſtice, by affrighting and chaſtiſing ſinful Men, at their approaches to the Earth; and not only ſo, but (as ſome have imagined) to be the place of their Habitation and Torment after Death. But ſuppoſing it to be ſo, yet herein is a kind Providence manifeſted, That their Returns to the Earth are but ſeldom (*a*), and their Stays ſhort, and that

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(*a*) There having of late been great Expectations among ſome, of a *Comet* appearing this year 1718, it may gratify their curioſity to take notice, in this place, of the three *Comets*, whoſe Periods we imagine, are diſcovered, by the great Sagacity and Application of our modern Aſtronomers. The Revolution of the *Firſt* of the Three, is ſuppoſed to be performed in 75 years; and that they take up many years in paſſing the reſt of their Orbs.

And now whether we conſider the due Situation of the greateſt part of the Heavenly Bodies, whereby neither they, nor their influences do interfere; or the more unuſual Poſition and Motion of Comets, ſtill it appears that a wiſe and careful Architect was the Contriver and Orderer of it all: eſpecially if we join what follows in the next Chapter.

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and to have been the ſame *Comet* that appeared in the year 1682. The *Second* is ſuppoſed to be the *Comet* that was ſeen in the year 1661, and to revolve round in 129 years. And the *Third* is imagined to be that *Comet* which appeared in 1680 and 1681, whoſe Period is 575 years. And, according to Mr. *Whiſton*'s Determinations, the *Firſt* of theſe three *Comets* will again appear in the year 1758, the *Second* in 1789, and the *Third* and laſt, not till about the year 2255.

CHAP. III.

Of the nice Proportions of the Diſtances of the Heavenly Bodies.

AS it is one great demonſtration of the ingenuity and skill of an Architect to give due Proportions to his Work; ſo we find this to be abundantly manifeſt in all the Bodies of the Univerſe, that fall under our cognizance: among which, we may diſcern a curious Order, and that due and nice Proportions are ſtrictly obſerved in their Situation.

How the Fixt Stars are ſituated in reſpect to one another, is impoſſible for us to determine at ſuch prodigious Diſtances as they are from us; but they look to us, who can have no regular proſpect of their Poſitions, as if placed without any Order: like as we ſhould judge of an Army of orderly, well diſciplined Soldiers, at a diſtance, which would appear to us in a confuſed manner, until we came near, and had a regular proſpect of them, which we ſhould then find to ſtand well in rank and file. So doubtleſs, if we could have an advantagious proſpect of the Fixt Stars, we ſhould find them very commodiouſly, and well ſet in the Firmament, in regard of one another. And this we have great reaſon to conclude, from the Rules of Parity, from that conſtant Harmony, and Similitude obſervable among all the works of the Creation, which fall under our cognizance: particularly this is evident in this Region of the Univerſe, to which we belong, and which we have a better Proſpect of, and can ſurvey with our Inſtruments,

ments, I mean the Syſteme of the Sun. In this we find every Body placed in good order, and at due diſtance, according even to the niceſt Rules of Proportion.

For the eviction of this matter, let us (according to the moſt received and rational Hypotheſis) ſuppoſe the Sun placed in the Center, to influence all his Planets with Light and Heat. Then follow the ſeveral Planets, ſurrounding him, not one here, and another there, at all adventures, in a rude manner, like a Work of *Chance*, but at due Diſtances from the Sun; at proper Diſtances from one another; and in ſuch well adjuſted proportion of their Velocities and Gravities, as makes the Squares of their Revolutions in proportion to the Cubes of their Diſtances. And this is what is diſcernible in the whole Solar Syſteme, not only in the Primary Planets that revolve round

the Sun, but in the Secondary Planets alſo, that revolve round them. Thus it manifeſtly is in the Five *Moons* that accompany *Saturn*, and the Four accompanying *Jupiter*. And a moſt ſagacious Contrivance this is, manifeſting the Preſence, and Conduct of the CREATOR, in thus chuſing this Proportion I ſpake of, rather than any other. For ſhould the power of Gravity (for inſtance) have been ſo conſtituted, as to decreaſe in the Proportion of the Cubes (inſtead of the Squares) of the Diſtances reciprocally; although it might be poſſible to adjuſt a Velocity, and I may add, a Direction too, ſo as to make Bodies deſcribe perfect Circles, yet the leaſt Exceſs or Defect of Velocity, or the leaſt Obliquity of the Direction, would make them deſcribe Spiral Curves, either aſcending *in infinitum*, or elſe deſcending to the Center. And ſup-
poſing

poſing the Orbs (in which thoſe Bodies move, and which are ſuppoſed, as I ſaid, to be made in proportion of the Cubes) to be perfectly Circular, the leaſt adventitious Force, even but of an Atom, abating or increaſing the Velocity, or changing the Direction, would bring on the aforeſaid Inconveniencies. And if the great CREATOR and Contriver of the Univerſe hath thus wiſely modelled, and cautiouſly methodized this part, this Syſteme of it where we live, and behold the thing, no great doubt can be made, but that he hath done the ſame in the other Syſtemes thereof alſo; that every Syſteme is ſet at a due Diſtance from one the other, and every Body in each Syſteme at its due Diſtance alſo from their Sun, or Fixt Star.

And now, who can reflect upon theſe things, and not perceive and admire the Hand that acteth in them, the

Contrivance and Power of an infinite Workman! For where we have ſuch manifeſt ſtrokes of wiſe order, counſel, and management, of the obſervance of Mathematical Proportions, can we conclude there was any thing leſs than Reaſon, Judgment, and Mathematical Skill in the caſe? or that this could be effected by any other Power, but that of an Intelligent Being, who had Wiſdom and Power ſufficient for ſuch a Work: according to the reaſoning of the *Stoick* in *Cicero*, who pleads thus (*a*): *If thou ſhouldſt ſee a large and fair Houſe, thou couldſt not be brought to imagine that Houſe was built by the Mice and Weeſles, although thou ſhouldſt not ſee the Maſter thereof: ſo* (ſaith he) *wouldſt thou not think thy ſelf very plainly to play the fool, if thou ſhouldſt imagine ſo orderly a*

(*a*) Cic. de Nat. Deor. L. 2. c. 6.

frame of the World, ſo great a variety and beauty of Heavenly things, ſo prodigious a quantity and magnitude of Sea and Land to be thy Houſe, thy Workmanſhip, and not that of the immortal Gods! And ſo when we ſee ſuch good order, ſuch due proportions in this Region of the Univerſe, and have good Reaſon to conclude the ſame may be throughout the whole, can we, without great violence to Reaſon, imagine this to be any other than the Work of GOD?

BOOK

BOOK IV.

OF THE MOTIONS OF THE HEAVENS.

CHAP. I.

That the bare Motion *of the Heavens and Earth are a Demonſtration of God.*

IN treating concerning the Motion of the Heavenly Bodies, it will be neceſſary to take in that of the Earth too, it being not eaſy to ſpeak of one without the other. And here there are two things that are manifeſt Demonſtrations of the Preſence and Management of GOD, namely, that ſuch Bodies ſhould move at all, and that their Motion is ſo regular.

1. That all thoſe vaſt Globes of the Univerſe ſhould have a Motion, muſt of Neceſſity be from ſome Being that had Power enough to put them in Motion. For as *Lactantius* well argues, (*a*) *There is indeed a Power in the Stars*, (and the like may be ſaid of the reſt of the Globes) of *performing their Motions, but that is the Power of God, who made and governs all things, not of the Stars themſelves that are moved.* For it is impoſſible for ſuch lifeleſs, dull, unwieldy Bodies to move themſelves, but what Motion they have, they

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(*a*) Lactant. Divin. Inſtit. L. 2. c. 5.

muſt receive from ſomething elſe able to move them.

Now this ſome will ſay may be effected by the *Vortices* ſurrounding the Sun, the Earth, or other primary Mover (*b*); or from a Vectorial Power, or Emanations of the Sun, (*c*) or other the like primary Movers carrying about and puſhing on ſuch Bodies as move about 'em. But allowing that it is poſſible it might be ſo, yet ſtill we muſt recur to ſome *firſt Mover*, ſome *primary Agent*, who was able to ſet that principal Mover into Motion: And then the Caſe amounts to much the ſame, and the Argument hath the ſame Force, whether we attribute the Motion of one, or all the ſeveral Globes to the Power of GOD. For in our Solar Syſteme, for Inſtance, if it

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(*b*) This was *Cartes*'s Notion, and of others long before him.

(*c*) This was *Kepler*'s Scheme.

ſhould be thought that the ſix primary Planets revolving round the Sun, received their Motion from his Revolution round his own Axis; yet *let us think* (as *Plato* argues) (*d*) *how it is poſſible for ſo prodigious a Maſs to be carried round for ſo long a time, by any natural Cauſe? For which Reaſon* (ſaith he) *I aſſert God to be the Cauſe, and that it is impoſſible it ſhould be otherwiſe.* Thus *Plato*, whoſe Argument is undoubtedly good, ſince, as *Ariſtotle* argues (*e*), *Every thing that is moved, muſt of Neceſſity be moved by ſome other thing; and that thing muſt be moved by ſomething that is moved either by another, or not by another thing. If it be moved by that which is moved by another, we muſt of Neceſſity* (ſaith he) *come to ſome prime Mover, that is not moved by another. For it is im-*

(*d*) *Plato* in Epinom.

(*e*) *Ariſtot. Phyſic.* L. 8. c. 5.

poſſible that what moveth, and is moved by another, ſhall proceed in infinitum.

And now therefore, if in our ſolar Syſteme, we ſhould imagine the Moon to be wheeled about our Earth, by the Motion and Vectorial Power of the Earth; and the Moons about *Saturn* and *Jupiter* by the Motion and Vectorial Power of thoſe Planets; and all the primary Planets to be turned round about the Sun by the Power of the Sun, yet at laſt we muſt find out a Mover of the Sun it ſelf, and thoſe other Primaries: A Cauſe of ſufficient Power to wheel about thoſe prodigious Maſſes, of ſuch vaſt Bulks, as have before been aſſigned to them, and which, beſides their own Weight, are, according to the former Hypotheſes, clogged and encumbered with the *Vis Inertiæ* of all thoſe Planets whether primary or ſecondary, or both, which they drive round. And if this was the Caſe, what Power can be found ſufficient for this Work, but that of the ſame infinite Hand that at firſt gave them Being!

And ſo for all the reſt of the moving Bodies of the Univerſe, ſuch as Comets, the new Stars before ſpoken of (*f*), and the ſlow Motion of the Firmament, or fixt Stars in 25920 (*g*) Years. This latter I ſhall ſay no more of, becauſe it may not ariſe from any Motion of the Firmament it ſelf, but from ſome other Cauſe (*h*). But for Comets, what Power

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(*f*) Book II. ch. 3.

(*g*) *Ptolemy* made this Motion to be one Degree in 100 Years. But others ſince make it to be more. Mr. *Street*, in his *Caroline Tables*, makes it 1 gr. 20′: *Hevelius* 1 gr. 24′. 46″. 50‴: but Mr. *Flamſteed* agrees *Riccioli*'s Numbers to come neareſt the Truth, *viz.* 1 gr. 23′. 20″. in 100 Years, or 50″ in a Year. According to which rate the Motion (called the *Platonick-year*) is accompliſhed in 25920 Years.

(*h*) Sir *Iſaac Newton* demonſtrates how this may

Power but that of the Almighty could give them ſuch prodigious Projections, as their Trajectories or Orbs are found to have? Orbs that run into ſuch amazingly long Ellipſes as approach to *Parabola's*, that 'tis wonderful how their projective Force ſhould carry them to ſuch immenſe Diſtances, and their Gravity at the ſame time bring them back and incomparably retain them in their Orbs.

And ſo for the new Stars, which I have ſaid are ſo many Signals of planetary Syſtemes diſperſed here and there all over the Univerſe, they are all of them ſo many Manifeſtations and Demonſtrations of an infinite Being that hath imparted Motion unto them: And they are a ſign alſo

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may ariſe from the Sphæroidal Figure of the Earth. *Princip.* L. 3. Prop. 21. & L. 1. Prop. 66. Corol. 20. See the matter alſo more eaſily demonſtrated in Dr. *Gregory's* *Aſtron.* L. 1. Prop. 64.

that there are other Globes beſides the Sun and its Planets, which are moving Bodies, even that all the Globes in the Univerſe are ſuch, and conſequently ſo many Proofs of an *Almighty firſt Mover.*

Thus the bare Motions of the Earth, and of the Heavens, are ſo many Arguments of a divine Power therein concerned. But we ſhall moreover find an infinitely wiſe, as well as almighty Power herein tranſacting, by what follows in the next Chapter.

CHAP. II.

The great Regularity *of the Motions of every Globe.*

HAVING in the preceding Chapter ſhewn that the giving Motion to ſuch immenſe, lifeleſs Globes, is the Work of God, we ſhall find much greater Demonſtration thereof, if we conſider that thoſe Motions are not at random, in inconvenient Lines and Orbs, but ſuch, as ſhew wiſe Deſign and Counſel. I ſhall here ſpecifie but two Examples, becauſe I ſhall have occaſion to ſay more of this Matter hereafter. One is, That all the *Planets* ſhould (when their Motions were impreſt upon them) have their Directions or Tendencies given, not in Lines tending from the Center to the Circumference, or very obliquely, but perpendicular to the *Radii*. The other is, That the Motions and Orbits of the Planets ſhould not interfere with one another, but tend one and the ſame Way, from Weſt to Eaſt, and lie in Planes but little inclined to one another, or when inclined, that it ſhould be very beneficially ſo, as I ſhall hereafter ſhew. Theſe and many other Inſtances, and in a word, that every Planet ſhould have as many, and various Motions, and thoſe as regular, and well contrived and ordered, as the World and its Inhabitants have occaſion for, what could all this be but the Work of a wiſe and kind, as well as omnipotent CREATOR, and ORDERER of the World's Affairs? A Work which is as plain a Signal of GOD, as that of a Clock, or other Machine is of Man. Thus *Tully's*

Tully's *Stoick* (*a*) argues our preſent Caſe from the *Shepherd* at *Actium*, when from the top of an Hill, he happened firſt to ſee a Ship ſailing in the Sea, he was for a while in great amazement, and ſurprize, to ſee ſuch a moving inanimate Body, and could not imagine of what a Nature it was poſſible it ſhould be, until he perceived, by ſome Tokens, that it was made and managed by Man. *So*, ſaith he, *the Philoſophers ought to have done, if haply they had any Doubts at the firſt View of the World: Afterwards when they ſhould behold its determined and equal Motions, and all Things managed by eſtabliſhed Orders, and with immutable Conſtancy; they ought then to underſtand that there is not only ſome Inhabiter in this heavenly, this divine Houſe, but alſo ſome Ruler and Moderator, and in a*

(*a*) De Nat. Deor. L. 2. c. 35.

manner, Architect of ſo great a Work, ſo noble a Performance. This Concluſion is ſo natural, ſo cogent, that any thing but *ſtupid prejudiced Blockheads* (as he ſaith thoſe Philoſophers were) would have naturally and eaſily made it. *But, now,* ſaith the Stoick (*b*), *they ſeem to me not ſo much as to have any Suſpicion of the wonderfulneſs of the Things of the Heavens or the Earth.* And great Reaſon the *Stoick* had for his ſurmiſe. For ſo manifeſt a Demonſtration of a Deity, are the Motions of the Heavens and Earth, that if Men *do* not ſee them, it is a ſign of great Stupidity; and if they *will* not ſee, and be convinced by them, it is as plain a ſign of their Prejudice and Perverſeneſs: As will farther appear by conſidering what an incomparable proviſion is made for the World's Good, by the particular

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(*b*) Ibid. c. 36.

cular Motions which are given to the Earth and Heavens, namely the *Diurnal* and *Periodical* Motions.

CHAP. III.

Of the Diurnal Motion *of all the ſeveral Globes.*

AS to the *Diurnal Motion*, there is great probability that our Earth, and all the heavenly Bodies have a Rotation round their ſeveral Axes; not all peformed indeed in the ſame Space, or Length of Time, but ſome in longer, ſome in ſhorter, times; each time making what we call a *Day*, in thoſe ſeveral Globes, equivalent, although not equal, to the Circumvolution of our Earth in 24 Hours.

This diurnal Rotation is viſible in many of the heavenly Globes, and highly probable in our own. In the *Sun* it is very manifeſt from the equable Motion of its Spots, which ſometimes appear in its Disk, and have been obſerved formerly by *Galilæo* (*a*), *Scheiner* (*b*), *Tardè* (*c*), *Malapertius*,

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(*a*) *Galilæus* tells in the third Dialogue of his *Syſtem. Mund.* that he was the firſt that diſcovered *Spots on the Sun*, in the Year 1610, which he ſhewed the next Year to divers great Perſons in *Rome*. That *Scheiner* ſent him two Letters by *Velſerus* under the feigned Name of *Apelles*, to deſire his Opinion of them, that he concluded them to be alterable, contrary to the received Opinion then, of the *Heavens Inalterability*, that they were contiguous to the Sun, and that their Path over the Sun, ſometimes in a Curve, ſometimes a ſtrait Line, argued the annual Motion of the Earth about the Sun, and not of the Sun about the Earth; with more to the ſame Purpoſe, which may be ſeen in the ſagacious Author in his firſt and third Dialogues.

(*b*) Vid. *Scheiner*'s Roſa Urſina.

(*c*) Vid. *Tardè*'s *Aſtra Borbonia*, who took 'em to be ſmall Stars interpoſing themſelves between the Sun and us. Of the ſame Opinion alſo was *Malapertius*, who gave them the Name of *Sydera Auſtriaca*.

tius, *Hevelius* (*d*) and our Countryman Mr. *Gaſcoigne* and Mr *Crabtrie* (*e*); and ſince them by Mr. *Boyle*, Dr. *Hook*, Dr. *Halley*, Mr. *Flamſteed* and others in *England*, and by Meſſieurs *Caſſini*, *Picart*, and others abroad (*f*); and of late by my ſelf and others too. Theſe Spots have manifeſtly a Motion, and the ſame Motion too, as that of a Globe moving round

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(*d*) See *Hevelius*'s Opinion of them at large in his *Selenography*, ch. 5. and in the *Appendix*.

(*e*) In their Letters (now in my Hands) there is an ingenious Controverſy between thoſe two great Men, Mr. *Gaſcoigne*, the Inventor of the Micrometer, and Mr. *Crabtrie*, concerning the *Solar Spots* that appeared about the Year 1640. which Mr. *Gaſcoigne* imagined to be great Numbers of ſmall Planets revolving round the Sun, at a ſmall Diſtance from him. Mr. *Crabtrie*'s Anſwer and Opinion may be ſeen in his Letter which is publiſhed with my own Obſervations about the *Solar Spots* from 1703 to 1711 in the *Philoſ. Tranſ.* N°. 330.

(*f*) The Obſervations of thoſe great Men (which are diſperſed about in *Ph. Tranſ.*) may be ſeen at one View in Mr. *Lowthorp*'s Abridgment, Vol. 1. p. 274.

upon its Poles: for we may perceive them to be perpetually ſhifting their Places from the Eaſtern to the Weſtern Limb of the Sun; and in thus doing, their daily Stages and Motion exactly correſpond to the Motion of a Globe; that is, thoſe Stages are ſhorter, and the Motion of the Spots ſeemingly ſlower towards the Sun's Limb, but near the Center of the Disk, larger and ſwifter; and all in exact Proportion to a double Line of Sines, or a Line of Sines on each Semidiameter of the Disk.

And farther yet, theſe Solar Spots, as they manifeſtly demonſtrate the Sun to be a moving Globe, turning round once in ſomewhat above 25 Days, ſo they manifeſt themſelves to be ſomething adhering unto, or nigh the Sun's globous Body, by means of the different Appearance they have in the different Parts and Poſitions of the Sun: As in the middle of the Disk, if they are round, towards the Limb they become more and more oval or long, juſt as ſuch a like Spot on a common Goble would appear when it is turned ſo as to be viewed by us ſideways or going out of ſight.

And laſtly, another thing obſervable in and from theſe Spots is, that they deſcribe various Paths or Lines over the Sun, ſometimes ſtrait, ſometimes curved towards one Pole of the Sun, ſometimes towards the other, exactly correſponding to the different Poſitions of the Earth in reſpect of the Sun, throughout all parts of the Year.

Thus in that vaſt Maſs, the Sun, we have manifeſtly ſuch a diurnal Motion as I ſpake of, or Circumvolution round its Axis; a Motion conſtant and regular, and doubtleſs of as great uſe to ſome office or other, in ſome part or other of the Univerſe, as the Motions of the Earth, are to the Inhabitants thereof: and a Motion therefore this is, demonſtrating the concurrence of the Almighty.

Neither is it the *Sun* alone that undergoes a *diurnal Rotation*, but moſt, if not all the Erraticks about him. *Saturn* indeed, is at ſo great a diſtance from us, that we have not been able to perceive whether or no he hath ſuch a Rotation; but as the other Planets have it, and there is full as much occaſion for it in *Saturn* as in them, ſo there is no great doubt to be made, but that he hath ſuch a like Diurnal Motion, accommodated as well to his ſtate, as it is in the Earth and the reſt of the Planets.

So *Jupiter* is diſcovered to have manifeſtly a Motion round upon its Axis from Eaſt to Weſt, in the ſpace of 9 h. 56', as Monſ. *Caſſini* (g) by many repeated Obſervations in the year 1665, and other following years, firſt found, from the Spots obſervable on it; of which there are two kinds, which I my ſelf have often ſeen as well as others before me, a ſhort account of which (although it be a Digreſſion) may not be unacceptable to many Readers. One kind of thoſe *Jovial Spots*, is only the Shadow caſt upon the Planet by the *Satellites* intercepting the Light of the Sun, when they are interpoſed between the *Sun* and *Jupiter:* the other are ſuch as are really in the body of that Planet, after the manner of thoſe we ſee in the Moon, but not permanent as they are. And by the motion of theſe latter Spots it is manifeſt, not only that *Jupiter* revolves round in the time mentioned, but that it is a moving Globe alſo, by reaſon (as was ſaid of the Sun) thoſe Spots move ſwifter, and in larger Stages towards the middle, than towards the Limb of *Jupiter*'s Disk. Alſo ſuch Spots as are round, about the middle, appear long or oval towards the Limb, or Edge of the Disk; as was before obſerved of the Sun's Spots.

(g) See his Obſervations in the *Memoirs de Mathem. & Phyſique* for *Jan.* 1692.

As to *Mars* and *Venus*, they are both diſcovered to have Spots, or Parts lighter and darker, as well as *Jupiter*, and to have a motion alſo as he hath. Of thoſe Spots in *Mars*, Dr. *Hook* had divers views in the year 1665, which he hath given us Figures of (*b*): and from thence concluded that Planet had a Motion, although he could not determine in what time it was performed. But M. *Huygens* expreſly ſaith (*i*) it is performed in the ſpace of 24 h. 40'. But for the motion of *Venus*, Monſ. *Caſſini* could perceive the

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(*b*) See Philoſ. Tranſ. N° 11, 14.
(*i*) Coſmotheor. p. 24.

Spots to change their place, and that the Planet had a Motion, although he could not make out what it was (*k*).

Thus are the Primary Planets diſcovered to have a *Diurnal Rotation*, or ſomewhat very like it at leaſt, all except *Saturn*, as I ſaid, and *Mercury*, and our own Globe. And as to theſe we have very little, or no Reaſon to imagine but that they move as well as the reſt; only we cannot perceive it in *Mercury*, by reaſon of its proximity to the Sun, and that its Elongations are never ſo great, nor ſo long, as to enable us to have any good and ſufficient Views of him with our Teleſcopes.

And as for our own Globe, it is very viſible that either that moves round in 24 hours, or that the Sun

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(*k*) Mr. *Caſſini*'s Obſervations diſperſed in the *Phil. Tranſ.* may be ſeen at one view in Mr. *Lowthorp*'s Abridg. Vol. 1. p. 383, & 425.

and all the Heavens move round it in the ſame time. And which of theſe two is the moſt agreeable to the uſual courſe and methods of Nature (which performs all its works in the moſt compendious, facile way) let every one judge. And is it not far the moſt compendious, ready, and eaſy way that the Terraqueous Globe ſhould wheel about in 24 hours, than that ſo many vaſt Bodies of the Heavens ſhould be turned about it in that time? Is it not as poſſible, yea as probable, that our leſſer Globe ſhould be ſo turned about, as thoſe more maſſy Globes of the *Sun*, *Saturn*, and *Jupiter* are about their Axes? But I ſhall not enter into a detail of the Arguments for the Earth's Motion, and the Objections made againſt it, becauſe I have done it in the Preliminary Diſcourſe.

Thus having taken a proſpect of the *Diurnal Motions* of the great

Globes of the Univerſe, that fall beſt under the cognizance of our Inſtruments, and found that many, and probably all of them, have a Rotation round in a determinate time; if to this we add the *Convenience* and prodigious *Uſe* of this Motion to the ſeveral reſpective Globes, we ſhall find that an infinitely *Wiſe* and *Kind*, as well as *Omnipotent Being*, was the *Orderer* thereof. For were thoſe Globes always to ſtand ſtill (eſpecially the Erraticks, that owe their Light and Heat to the Sun) in this caſe, one half of them would be dazelled and parched with everlaſting Day, whilſt the other would be involved in everlaſting Night and Darkneſs. And what the conſequences would be, we may beſt judge from what would befall our own Globe, without the kindly Alternations of Day and Night; and that is, that it, at leaſt a great part of it, would ſcarce be habitable, it would neither agree to the ſtate of Man, or any other Animals; nor to that of Vegetables, or indeed any other Creature. For one half of the Globe would be burning up, at leaſt too much drying, and exhauſted with the Beams of the Sun, whilſt the other would be immerged in, and deadened with too long Night. And in ſuch a caſe, how could the great Works of Nature, ſo ſerviceable to the World, be performed? How, for inſtance, could the Vapours be rais'd to ſupply the Earth with cooling Clouds and fertile Showers? How could the Winds be excited to fan the Atmoſphere with their pleaſant and healthful Gales? How could the Tides be produced, which by their conſtant agitations keep the Waters ſweet and clean, and prevent their poyſoning the World?

And as the Courſe and Functions of Nature, would be thus affected, ſo would the State of the Creatures be no leſs. For how could thoſe of the Vegetable Kingdom be animated and excited by the kindly Heat of the Day, and then again tempered and invigorated by the no leſs kindly Dews, and Influences of the Night? How could Men and all other Animals diſpatch their Buſineſs, gather their Food, and perform all the various labours and offices of the Day, and then recruit and repoſe themſelves with reſt, ſleep, and due perſpiration, and whatever elſe may be owing to the ſalutiferous Influences of the Night, and abſence of the Sun?

Theſe and ten Thouſand as great Inconveniences as theſe, would be the certain Events of the want of this Diurnal Motion of our Globe. And as the reſt of the Globes have their

Shares in the like Motion, ſo we may very reaſonably imagine that it is no leſs uſeful and beneficial to them than it is to us, and that the Inconveniences of the want of it would be as great.

CHAP. IV.

Of the Annual or Periodical Motion *of the Primary Planets.*

BESIDES the Motion treated of in the preceding Chapter, there is another, which is as clear a Manifeſtation of the great CREATOR as that, namely, the *Periodical* or *Annual*, which is viſible in ſome of the great Globes, and probable in many others. Among the Fixt Stars it is highly probable ſomething

thing of this Nature is: as appears from thoſe New Stars which I have before taken notice of, which, as I have ſaid, ſometimes become viſible to us, in one Part of their Orbits, and again diſappear in other Parts of them. But theſe Syſtemes being out of the Reach of our beſt Glaſſes, I ſhall paſs them by, eſpecially becauſe in our own Solar Syſteme, we have abundantly enough to entertain us in this Demonſtration of GOD.

For it is very viſible, without the Help of the Teleſcope, that every *Planet* of the *Solar Sſteme* hath this *Periodick Motion* I am ſpeaking of. For it is manifeſt that either the Sun and the Planets move about the Earth, the one in the ſpace of a year, and the reſt in other times; or that the Earth and the other Planets move about the Sun in ſuch times. But let us (as I have all along done) ſuppoſe the latter, that the Sun ~~it~~ fixt in the is Center, without any other but its Diurnal Rotation in $25\frac{1}{4}$ days: in this caſe we ſhall have the ſeveral Primary Planets revolving round the Sun in an excellent and due Order, by the exacteſt Rules of ſuch a noble Structure, ſuch an admirable Oeconomy, and that is *in Times* (as I ſaid) *in ſquare proportion to the Cubes of their Diſtances.* So that we ſee *Mercury* to perform its Period in near 88 Days: *Venus* (the next in order to the Sun) its Period in ſomewhat above 224 Days: then the *Earth*, with its Companion the *Moon*, in $365\frac{1}{4}$ Days: then *Mars* in about 687 Days: next him *Jupiter* in about 4333 Days: and laſtly, *Saturn* in ſomewhat above 10759 Days.

To this ſo ſtrict an Order of the *Periods* of thoſe Planets, we may add the conſideration of the different *Paths* of their *Periodical* and *Diur-*

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nal Motion; that they lie not in a very different Plane, as quite acroſs, or the like; nor exactly in the ſame Plane, but a little croſſing one another; the Diurnal Courſe lying in, or parallel to the Equator; but the other in the broad path of the Zodiack at an inclination of 23½ Degrees.

And a glorious Contrivance this is for the Good of our Globe, and doubtleſs no leſs for all the reſt that ſympathize in the like Motion. For was the Earth's Periodick Motion to be always in the ſame Plane with that of the Diurnal, we might indeed be ſometimes nearer to, and ſometimes farther from the Sun; but at the ſame time miſs of thoſe kindly increaſes of Day and Night, together with ſuch uſeful directions of the Sun-beams, which the advances of the Earth to one or other of the

Poles cauſe (*a*): which two things are the real Cauſes of our Seaſons of Summer

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(*a*) There are two Cauſes of the great difference between the Winter and Summer, Heat and Cold. One is the ſhorter or longer continuance of the Sun above the Horizon: in Summer long, which increaſes the Heat, as much as it lengthens the Day: in Winter ſhort, which diminiſhes the Heat, as it ſhortens the Day; and augments the Cold, as it lengthens the Night. The other Cauſe is the Oblique or Perpendicular Direction of the Sun's Rays, the Oblique being weaker than the Perpendicular; as is evident from *Galilæo*'s Experiment, in his *Syſtema Mundi*, *Dial.* 1. by holding a Paper turned up at right Angles, or a Book half open; over againſt an illuminated white Wall; where it may be obſerved that the Side oppoſite to the Wall, which the Rays ſtrike perpendicularly, is far more light and white than the other Side, on which the Rays fall obliquely. The ſame it is in the Incidence of the Sun's Rays on any Plane, namely, the Rays are ſo much ſtronger, and the Plane the more warmed and enlightened, as the Rays are more or leſs Perpendicular; and that on two Accounts; 1. Becauſe the Perpendicular Rays ſtrike with greater force than the Oblique. As in Fig. 4. the Rays *R R* ſtrike the Plane *A P* more forcibly than the Plane *O B*. The Action or Force of which Percuſſion is (like that of all other Impulſes) as the Sine of the Angle of Incidence.

Summer and Winter, Spring and Autumn, and not our being nearer unto,

dence. So the Force of the Rays *RR* upon the Oblique Plane *OB*, is as the Sine only of *ROB*, whereas their Force upon *AP* is as the whole Sine of 90 Degrees, or Angle *ROP*. 2. Another Reaſon is, That a greater Number, or Quantity of Rays, fall within the Compaſs or Area of any Plane, in a perpendicular, than oblique Direction. This will be manifeſt from the bare inſpection of *Fig.* 4. where it may be obſerved that all the Rays between *RR* and *Op* fall on the Plane *AP*; but only about one half of them would fall upon an oblique Plane of the ſame Length, if it was *Ob*: Or (which is the ſame thing) near as many Rays would fall off *Ob*, turned up to *Ob*, as fall upon it. Alſo it may be obſerved farther, that as the Line *OB* is longer than *Op* ſo are the Spaces between the Rays larger in *OB* than *Op*; and conſequently fewer Rays fall on *OB* for its Length, than on *Op* for its Length, or the Rays are denſer, or more compact in *Op* than *OB*. And when they are ſo, they are ſo much the ſtronger, as is evident from the collecting and condenſing the Sun's Rays by a Burning-glaſs.

What the particular Power of the Sun's Rays is in all Directions, Quantities, and Impulſes, falls under Mathematical Calculation; but I need not trouble the Reader with it, but ſhall refer to the ingenious Dr. *Wolfius* (Mathematical Pro-

feſſor

to, or farther from the Sun. For thoſe Benefits (we at leaſt that inhabit towards the Northern Pole) have at the contrary Seaſon, when we have moſt need of them, *viz.* the Sun's Proximity, in Winter; its greater Diſtance from us in Summer; as is manifeſt from the Increment of its apparent Diameter in Winter to 32′. 47″, and the Decrement thereof in Summer to 31′. 40″. (*b*).

And

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feſſor of *Hall*) his *Elementa Aerometriæ.* And as for the proportional Degree of the Sun's Heat in all Latitudes, and its Altitudes, our moſt acute *Savilian* Profeſſor, Dr. *Halley*, hath given us a neat and clear Method for computing it in *Philoſ. Tranſ.* N° 203.

(*b*) Monſieur *de la Hire* in his *Tabul. Aſtron.* makes the Sun's Semidiameters to be *Dec.* 30. 16′ 22″ and *Jun.* 30. 15′ 49′. But Mr. *Flamſteed* in his *Lunar Tables* added to Mr. *Horrox*'s *Poſthumous Works* makes the greateſt to be 16′ 23′, the leaſt 15′ 50″ and the *French Academiſt* 16′ 23″ and 15′ 50″. *V. Recueil d' Obſerv. Les Elemens d' Aſtron.* p. 22.

Beſides the Alteration of the Sun's apparent Diameter, its ſwifter Motion in Winter about the

And now for a Concluſion of this Chapter concerning the Periodick Motions of the Primary Planets, we may take up the Argument of *Hugo de S. Victore* (*c*), *Who commandeth the Sun to deſcend through the Winter Signs? And who again cauſeth him to aſcend through the Summer Signs? Who leads him from Eaſt to Weſt? And who again brings him back from the Weſt to Eaſt? All theſe things are very wonderful, but to God alone poſſible.*

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the Solſtice by about a 15th part, is an Argument of its being then nearer the Earth. From whence it comes to paſs that from the Vernal to the Autumnal Æquinox, there are about 8 Days more, than from the Autumnal to the Vernal.

(*c*) *Quis ſolem per hyberna deſcendere ſigna præcipit? Quis rurſum per æſtiva ſigna aſcendere facit? Quis eum ab Oriente in Occidentem ducit? Quis iterum ab Occidente in Orientem revehit? Hæc cuncta ſunt mirabilia, ſed ſoli Deo poſſibilia.* Didaſcal. L. 7. c. 8.

CHAP. V.

Of the Periodical Motion of the Secondary Planets.

HAVING conſidered the Periods of the *Primary Planets*, let us next caſt our Eye upon thoſe of their *Secondaries*. And among theſe we ſhall find the ſame compleat Order and Harmony as among the laſt. Thus *Saturn*'s five Moons, and *Jupiter*'s four, and our own about the *Earth*, have each of them their determinate Times, ſome longer, ſome ſhorter Intervals of Time, in the ſame due Proportion, as I ſpake of among the Primaries.

Beſides which, there is another Thing very conſiderable in this periodical Motion of thoſe Secondary

Planets, and that is, that it is mixt with a kind of *cochleous* Direction towards one or other Pole of the primary Planet; by which means every *Satellite*, by gentle Degrees, makes its Viſits towards each Pole of its *Primary*. This is well known among the *Circumjovials* for inſtance, that they all have a ſlow and gradual ſcrew-like progreſs, firſt towards one, then back again towards the other Pole of *Jupiter*: and that each *Satellite* hath its Declination greater and greater, according as it is farther or farther from *Jupiter*'s Body. Accordingly the Declination of each *Circumjovial*, aſſigned by the diligent and ſagacious *Caſſini* (*d*), after twelve Years Obſervations, are theſe, The greateſt Declination of the

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(*d*) *Les Hypoth. & Les Tables des Satel. de Jupiter*, §. 4. in the *French* Academiſt's large Collection.

Firſt, or *Neareſt*, exceeds not a third part of *Jupiter*'s Semidiameter: that of the *Second* ſurpaſſeth but a little of a quarter of its Diameter: That of the *Third* a little exceeds three quarters of the Diameter: And that of the *Fourth*, or *Outermoſt*, goes beyond *Jupiter*'s Poles by a third part of the Semidiameter. All which Mutations, he ſaith, are performed in the ſpace of 12 Years. Thus the famous *Caſſini*. But I have my ſelf obſerved a greater Vagation in the *third Satellite*; that it advanced near to, if not even with the very Limb or Pole of *Jupiter*, and that its Stay in *Jupiter*'s Shadow, or the Duration of its Eclipſe at that Time, was leſs than is commonly aſſigned unto it, as it is reaſonable to imagine it ſhould be, becauſe the *Satellite* had only the outſide of the Cone of *Jupiter*'s Shadow, and conſequently a leſſer part thereof to paſs thorough at that Time.

As to the End and Uſe of this ſo obſervable a Tendency in the Secondaries towards each Pole of their Primaries, we may gueſs at it from what hath been ſaid of the like Tendency of the Primaries towards the Sun, on which our Seaſons do depend: So thoſe Secondaries moving in like manner to each Pole, effect ſome of the grand Works of the divine Providence from Pole to Pole, illuminate all parts of their reſpective Globes, contract the length of their Nights (as ſhall be ſhewn in proper place,) move their Waters, and excite their Tides, and perform other ſuch great Works of Nature, as with good Reaſon, we attribute to the Influx of our Moon here in our own Globe.

And can ſuch well contrived, ſuch uſeful Motions, that the World could not ſubſiſt without, that Nature could not do its grand Works without, can theſe be other, than the *Fiat* of an infinitely *indulgent*, as well as *wiſe* CREATOR! Could this Conſonancy be ſo univerſal, among all the Globes that fall within our View? Could their Periods, and Diſtances, be in the ſame due proportion all the Univerſe over, their Motions all ſo alike, had they not had the ſame *Contriver* and *Maker!* But I ſhall cloſe this Argument with the Reflexion of the moſt ingenious Mr. *Molyneux* (*b*), who ſpeaking of the ſeſquiplicate proportion of both the primary and ſecondary Planets, thus concludes: *And from hence may we juſtly fall into the deepeſt Admiration, that one and the ſame Law of Motion ſhould be obſerved in Bodies ſo vaſtly diſtant from each other, and which ſeem*

(*b*) *Dioptr. Nov.* Par. 2. c. 6. §. 12.

to have no Dependance or Correſpondence with each other. This doth moſt evidently demonſtrate that they were all at firſt put into Motion by one and the ſame unerring Hand, *even the infinite* Power *and* Wiſdom *of* God, *who hath fixed this Order among them all, and hath eſtabliſhed a Law which they cannot tranſgreſs. Chance or dull Matter could never produce ſuch an harmonious Regularity in the Motion of Bodies ſo vaſtly diſtant: This plainly ſhews a Deſign and Intention in the firſt Mover. And with ſubmiſſion to the reverend and learned Divines, I am apt to think that one Argument drawn from the Order, Beauty and Deſign of Things, is more forcible againſt Atheiſm, than multitudes of notional Proofs*, &c. Thus Mr. *Molyneux*. But we ſhall find farther Evidences of this *ſupreme Management* in theſe Matters from what follows in the next Chapter.

CHAP. VI.

The Conſtancy and Regularity of all the Motions of the Earth and Heavens.

THAT the Earth and Heavens move at all, but eſpecially that they have ſuch particular and beneficial Motions, appears, from the preceding Chapters, to be the Work of God. And the Concurrence of the ſame infinite Hand is as manifeſt in the Perpetuity, Conſtancy, and Regularity of thoſe Motions. For without this *Almighty Guide* and *Manager*, how is it poſſible that all thoſe vaſt and unwieldy Maſſes ſhould continue their beneficial Motions throughout all Ages? ſhould perform their uſeful Stages without any the leaſt Intermiſſion, Interruption or Diſorder that we know of? What Motion, what Contrivance, what piece of Clockwork was there ever under the whole Heavens, that ever came up to ſuch a perfection, and that had not ſome Stops or ſome Deviations, and many Imperfections? But yet none was ever ſo ſtupid as to conclude ſuch a Machine (though never ſo imperfect) was made by any other than ſome rational Being, ſome Artiſt that had Skill enough for ſuch a Work. As he in *Cicero* (*a*) argues from his Friend *Poſidonius*'s piece of Watch-work, that ſhewed the Motions of the Sun, Moon and five Erraticks; that if it had been carried among the *Scythians* or *Britains*, *Quis in illâ barbarie dubitet, quin*

(*a*) De Nat. Deor. L. 2. c. 34.

ea Sphæra ſit perfecta Ratione? with more to the ſame purpoſe: No Man even in that State of Barbarity would make any doubt, whether it was the workmanſhip of Reaſon or no (*b*). And is there leſs Reaſon to imagine thoſe Motions I have been treating of to be other than the Work of God, which are infinitely more conſtant and regular than thoſe of Man! Or to uſe the laſt mentioned *Stoick's* Argument, can it be thought that *Archimedes was able to do more in imitating the Motions of the Heavens* (in his Sphere) *than Nature in effecting them?*

And now to reflect upon the whole, and ſo conclude what hath been ſaid concerning theſe ſeveral Motions: We may all along perceive in them ſuch manifeſt ſignals

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(*b*) See the Place cited at large in my *Phyſico-Theology*, p. 2.

of a divine Hand, that they all ſeem, as 'twere, to conſpire in the Demonſtration of their infinite CREATOR and ORDERER. For beſides what in all probability is in other parts of the Univerſe, we have a whole Syſteme of our own, manifeſtly proclaiming the **Workmanſhip** of its *Maker*. For we have not thoſe vaſt and unwieldy Maſſes of the Sun, and its Planets, dropt here and there at random, and moving about the great *Expanſum*, in uncertain Paths, and at fortuitous Rates and Meaſures, but in the compleateſt manner, and according to the ſtricteſt Rules of Order and Harmony; ſo as to anſwer the great Ends of their Creation, and the divine Providence; to diſpatch the noble Offices of the ſeveral Globes; to perform the great Works of Nature in them; to comfort and cheriſh every thing reſiding on them, by thoſe uſeful Changes of Day and Night, and the ſeveral Seaſons of the Year.

Theſe things are ſo evident to the Reaſon of all Men, that *Tully* might well make his *Stoick* to alledge this as one of his principal Arguments for the proof of a Deity (*c*); *The fourth Cauſe*, ſaith he, *and that even the chief, is the Equality of the Motion, and the Revolution of the Heavens; the Diſtinction, Utility, Beauty and Order, of the Sun, Moon, and all the Stars: The bare View alone of which things is ſufficient to demonſtrate them to be* no Works of Chance. *As if any one ſhould come into an Houſe, the Gymnaſium, or Forum; when he ſhould ſee the Order, Manner and Management of every Thing, he could never judge theſe things to be done with-*

(*c*) De Nat. Deor. L. 2. c. 5.

out an Efficient, but muſt imagine there was ſome Being *preſiding over them, and whoſe Orders they obeyed. So much more in ſo great Motions, ſuch Viciſſitudes, and the Orders of ſo many and great things; —— a Man cannot but conclude, that ſuch great Acts of Nature are governed by ſome Mind,* ſome intelligent Being.

And ſo again afterwards (Chap. 21.) when, among other things, he had been ſpeaking of the Motions of the Planets, he thus argues, *I cannot poſſibly underſtand,* ſaith he, *how all this Conſtancy can be among the Stars; this ſo great Agreement of Times through all Eternity, among ſuch various Courſes* (how this can be) *without ſome Mind, Reaſon and Counſel.* And a little after this, ſpeaking of the Fixt Stars, he ſaith, *But the perennial, and perpetual Courſes of thoſe Stars, together with their admirable and incredible Conſtancy, declare*

clare a divine Power and Mind to be in them. And this he takes to be ſo plain a Caſe, that he that could not diſcern it, he thinks could diſcern nothing. And then he thus concludes, *In the Heavens then, there is neither any Chance, nor any Temerity, nor Error, or Vanity; but on the contrary, there is all Order, Truth or Exactneſs, Reaſon and Conſtancy. And ſuch Things as are void of theſe are counterfeit, falſe, and full of Error. ——He therefore that thinks the admirable cæleſtial Order, and incredible Conſtancy, on which the Conſervation and Good of all Things depend, to be void of a Mind, he himſelf deſerves to be accounted devoid of a Mind.* Thus with great Force and Reaſon, *Tully's Stoick* rightly infers the Preſence and Concurrence of a Divine Being, and Power, from the Motions of the Heavens: Only not being aware who that Being was, he erroneouſly imagines the heavenly Bodies themſelves to have Divinity, and puts them therefore into the Number of the Gods; which Error is excellently refuted by *Lactantius* in his *Inſtit. Divin.* L. 2. c. 5, &c.

BOOK

BOOK V.

OF THE
FIGURE
Of the ſeveral
GLOBES of the Univerſe.

CHAP. I.

The Conſonancy of all the Globes *in their Spherical Figure.*

HAVING in the preceding Book manifeſted the *Motions* of the Earth and Heavens to be the Contrivance and Work of GOD, I ſhall enquire in this, whether their *Figure* be of the ſame kind, wiſely ſuited to the Motions, and in a word to the whole State and Convenience of the ſeveral Globes, ſo as to manifeſt it ſelf to be the Work of GOD?

Now as to the *Figure*; it is obſervable in the firſt place, that there is a great Conſent therein, among all the Globes that fall under our view, and that is, that they are all Sphærical, or nearly ſo, namely, Sphæroidal (*a*). Thus all the Fixt Stars, ſo far as we are able to behold them, either with our naked Eye, or our Glaſſes: Thus the Sun, and thus all its Planets, and thus the Secondaries, or Moons accompanying *Saturn*, *Jupiter*, and our *Earth*. And although *Venus*, *Mercury*, and our *Moon* have *Phaſes*, and appear ſometimes Falcated, ſometimes Gib-

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(*a*) See *Phyſico-Theol.* B. 2. ch. 1. Note *a*.

bous, and ſometimes more or leſs round, and even *Mars* too, in its Quadratures, becomes Gibboſe; yet at ſuch times as theſe Planets ſhew their full Phaſes, they are found to be ſpherical, and only loſe this Figure by virtue of their Poſition to the Sun, to whom they owe their Light. And this Sphericity, or Rotundity is manifeſt in our *Moon*, yea and in *Venus* (*b*) too; in whoſe greateſt Falcations the dark Part of their Globes may be perceived, exhibiting them-

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(*b*) What I have here affirmed of the *Secondary Light* of *Venus*, I have been called to an account for, by an ingenious Aſtronomer of my Acquaintance. But I particularly remember, that as I was viewing *Venus* ſome Years ago, with a good 34 foot Glaſs, when ſhe was in her *Perigee*, and much *horned*, that I could ſee the darkened Part of her Globe, as we do that of the *Moon* ſoon after her Change. And imagining that in the laſt total Eclipſe of the Sun, the ſame might be diſcerned, I deſired a very curious Obſerver that was with me, and look'd through an excellent Glaſs, to take Notice of it, who affirmed that he ſaw it very plainly.

ſelves under the Appearance of a dull, and ruſty colour.

And as this ſpherical Figure holds in every of the Globes at a diſtance from us, ſo we may reaſonably imagine our own Globe to be conſonant to the reſt. But indeed we have great Reaſon to conclude it to be ſo, from the Curvity of its Shadow in its Eclipſes of the Moon; from the Diſcovery of new Conſtellations in the Heavens, as we change our Hemiſphere, and make Approaches towards either Pole; from the Surface of the Sea, which appears to be of this Figure, by our gradually diſcerning far diſtant Objects, Mountains, Towers, Sails of Ships, *&c.* the Parts of which are more and more ſeen, as we approach nearer and nearer to them: With other Arguments to the ſame purpoſe, which I need not enumerate in a Caſe now generally owned to be true.

Chap. II.

Of the Inequalities, or Hills and Vales obſervable in the Earth and Moon.

HAVING in the preceding Chapter demonſtrated the ſeveral Globes of the Univerſe to be Spherical, it is not to be underſtood that theſe Globes are ſtrictly ſo, but an Allowance is perhaps to be made for the Difference between their Æquatorial and Polar Diameters, before ſpoken of: But eſpecially for thoſe little and inconſiderable Excreſcences of the Hills, very manifeſtly diſcernable in the Moon (*c*), as well

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(*c*) Every one that hath viewed the *Moon* with but an ordinary Glaſs, eſpecially, when ſhe is not round, may eaſily perceive conſiderable Uneven-well as in our own Globe; which I call little and inconſiderable, eſpecially

evenneſſes; that ſome Parts are manifeſtly higher and others lower. About the Quarters, divers bright golden Spots may be ſeen in the ſhaded Part, at ſome diſtance from the enlighten'd Part; and theſe may be perceived to grow larger and brighter, as the ſhady Part turns more and more towards the Sun; till at laſt you may ſee all the intermediate Vallies between thoſe Spots, and the other enlighten'd Parts. Alſo in divers Parts of the *Moon*, eſpecially ſuch as border on the ſhaded Part, there may be obſerved to be certain Holes or Pits, black, dark, or ſhady, when the Parts encompaſſing them are illuſtrious and bright. And this Darkneſs, as if under ſome Mountain, lies always on the Side next the Sun, and gradually goes off, as the Hole, Pit or Valley turns more and more towards the Sun, till at laſt the whole Valley is enlighten'd, and looks like a depreſſed Ground in the Body of the *Moon*. All which things are manifeſt Signals that the *Moon*'s Surface is not even and ſmooth, but like that of the Earth, full of Hills and Valleys.

Which Opinion, although now well grounded on ocular Demonſtration, was as old or older than *Plutarch*'s Days, who in his Book *de Facie in orbe Lunæ*, at the Beginning, cites it as *Clearchus*'s Opinion, Εἰκόνας ἐσοπτρικὰς εἶναι τὰ εἴδωλα τῆς μεγάλης Θαλάσσης—i. e. *That what is called the Face of the* Moon, *are the Images and Appearances of* cially thoſe in the Earth, becauſe they are ſo in proportion to the Earth's Diameter; as will appear by coming to particulars. The Diameter of the terraqueous Globe I have ſhewn in my *Phyſico-Theol.* (*b*) to be about 7935 *Engliſh* Miles, and in this Book to be (*) 7967 Miles: But that of the Hills is no more than a few Miles. *Snowdon* in *Caernarvonſhire* (the higſteſt Mountain in all our Iſland) is but 1247

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of a great Sea in the Moon. And about the middle of that Tract, Τὸ δὲ φαινόμενον τȣτὶ πρόσωπον —— i. e. *As to that Face which appears in the* Moon: *As our Earth hath certain large Bays; ſo we conceive the* Moon *is over-ſpread with large Hollows and Ruptures, containing Water, or a thick dark Air, into which the Sun-beams are not able to enter, and ſo no Reflexion is made by them.*

As to other Matters in which the Earth and *Moon* ſeem to agree, as in Seas, and great Collections of Waters, an Atmoſphere, &c. I ſhall paſs them by here, as improper for this Place.

(*b*) Book 2. Ch. 2. Note.

(*) Book 1. Ch. 2. Note *a*.

yards (*c*); the *Alps* themſelves but about two *Engliſh* Miles (*d*): Nay the very *Pike of Tenariffe*, one of the higheſt ridges throughout the Globe, unleſs we except the high Mountains of *Peru* called by *Joſ. Acoſta* (*e*) *Periacaca*;

(*c*) In the Journal of the late ingenious *Richard Townley*, Eſq; of *Townley* in *Lancaſhire*, I find this Note upon *Sept. 6. 1682. This Day Mr.* Adams *called here, who is taking a Survey,* &c. *He told us that with repeated trials he had found* Snowdon-hill 1320 *Yards higher than the Highwater-mark, and that the Quickſilver ſtood at the Bottom at 29 Inches; at the Top of the Hill 25'96: So that 1320 gave 3'04.* Then follows this Note, *viz. Mr.* Adams *coming ſince tells me, that the Height of* Snowdon *was but 1247 Yards, which gave 3'04.*

The Reaſon of this Difference of 73 Yards, in the height of *Snowdon*, I take to be, that the firſt Meaſure was made by Mr. *Adams* himſelf, the latter by Mr. *Caſwell* with Mr. *Adam*'s Inſtruments: And probably the former is the Height above the Sea, the latter only above ſome Plane.

(*d*) Mr. *Nic. Fatio* told me that he had meaſured the Height of the *Montagne Mauditi*, which is one of the higheſt Ridges of the *Alps*, and that he found it to be 2000 French Toiſes above the *Lake* of *Geneva*, which is equal to 12816 Engliſh Feet, or 2'42 Miles.

(*e*) *Acoſta* ſaith, the *Alps* ſeemed to theſe Mountains *riacaca*; or that near St. *Martha* (*f*); or thoſe called the *Andes* (*g*); this Ridge (I ſay) is computed to be but between 3 and 4 Miles perpendicularly above the Sea (*h*). All which Eminences, compared with the Diameter, or Semidiameter of the Earth, is no more than as a particle of Duſt is to a large Globe, on which it reſteth.

And ſo likewiſe for the Mountains viſible in the *Moon*, although ſome

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tains he travelled over, but as ordinary Houſes to lofty Towers. See my *Phyſico-Theol.* B. 1. ch. 1. Note *b*.

(*f*) Capt. *Dampier* ſaith that he is of Opinion, that the Hill near St. *Martha* is higher than the *Pike of Tenariffe*. Voyage round the World, p. 24.

(*g*) Of the *Andes* of *Chili* and *Peru*, Capt. *Dampier* ſaith, *Theſe are the higheſt Mountains I ever ſaw, far ſurpaſſing the* Pike of Tenariffe, *or* Santa Martha, *and I believe any Mountains in the World.* Ibid. p. 95.

(*h*) See Dr. *Hooke*'s Account of the *Pike of Tenariffe* from his Friend Mr. *G. T.* who went to the Top of it; at the End of his *Lectures concerning Springs*, p. 42.

of them are of that height (*i*), as to reflect the Light of the Sun from their

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(*i*) By *Riccioli*'s Meaſures, the Height of what he calls *Mount Sinai*, or St. *Katherine*'s Hill, is 9 *Bononian* Miles, and that of *Xaverius* 12, but according to his Corrections, the former is but $8\frac{14}{25}$ Miles, the latter $11\frac{1}{2}$. Which at the rate of 6020 *Engliſh* Feet in a *Bononian* Mile, is about 13 and 9 *Engliſh* Miles; an Height ſo great, conſidering how much the Moon is leſs than the Earth, that I cannot but think that diligent Perſon was miſtaken in his Meaſures, and that the Computations of *Hevelius* are much the beſt: Who as he was as able as any Man, and made more accurate and diligent Obſervations of the *Moon*'s Face, than moſt Men ever did; ſo he was more likely to come neareſt the Truth. And by his Reckoning, the higheſt Hills in the *Moon* are but about three quarters of a *German* Mile; and ſome of them but ſeven ſixteenths; and ſome not above an *Italian* Mile. And conſidering the Bulk of the *Moon* to that of the Earth, theſe are great Eminences for the *Moon*.

And as the *Lunar Mountains* are of ſo prodigious Heights, ſo many of them are of great Extent. *Hevelius* reckons the *Lunar Taurus* to reach to 170 *German* Miles; Mount *Sepher* 150; and the *Lunar Apennine* above 100 *German* Miles.

The Way how to meaſure the Height of the Mountains of the *Moon*, is not difficult, nor uncertain; which is, by obſerving the Diſtance between their lofty Tops ſome Days before ever it reacheth the Vallies beneath them, yet on the *Moon's* Limb we can diſcern nothing of them: But

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tween the diſtant golden Spots, at their firſt appearance (which are the Tops of Hills) and the enlightened Part of the *Moon*. Which Diſtance may be computed by Miles, or any other equal Parts, into which we can imagine the *Moon's* Diameter divided. Thus in Fig. 5. *ARB* is a Part of the *Moon*'s Circumference, one Part of which *AR* is enlightened, the other Part *RB* is in darkneſs. *Hi* is a Mountain, whoſe Top *H* is touched by the Sun-beams, ſhining from *S* the Sun to *R*, and reaching to *H*. Now ſuppoſing the Semidiameter of the *Moon RC*, to be 274 *German* Miles, according to *Hevelius*, the Length of the Side *RH* (or Diſtance between the Top of the Hill, and the Edge of the enlighten'd Part) will be found alſo to be a 10th, 20th, or other Part of that Semidiameter or Diameter; or ſome certain Number of Miles. And then we have the two Sides *RC*, 274 Miles, and *RH*, and the right Angle included between them; by which, both the other Angles, and the Side *CH*, may be found by a common Caſe of Right-angled Triangles. Out of which Side *CH*, deducting the *Moon*'s Semidiameter 274, there remaineth the Height of the Mountain *H i*. Conſult here *Hevel. Selenogr.* ch. 8. *Galilæus Nunc. Sider.* p. 14. *Riccioli Almageſt.* L.4. c. 8. Schol.

ſo far from that, that, on the contrary, the Edge through our beſt Glaſſes looks like an even, ſmooth, and uninterrupted Circle (*k*).

Although

(*k*) The Edge of the *Moon*, which I here mean, is that next the Sun; on which I could never perceive with my beſt Glaſſes any the leaſt Sign of a Mountain, but all to be exactly level and ſmooth. Only indeed there are ſome certain tranſient roughneſſes and unevenneſſes on the Limb cauſed by Vapours, eſpecially when the *Moon* is near the Horizon, and in windy, and ſome other Weather. At which times, the Motion of the Air and Vapours, makes a pretty Criſpation, and Rouling, like Waves on the *Moon*'s Limb, which have the Appearance of moving Mountains and Valleys. But on the oppoſite Side, if the leaſt Portion of the darken'd Part of the *Moon*, extends beyond the enlightened Part, Mountains may very manifeſtly be diſcerned, exactly reſembling ours on the Earth. A few Hours before and after the Full, I have with Pleaſure ſeen the Appearance of conſiderable Mountains and Bays. One of which Views, I have given in Fig. 6. which is the *Moon*'s Appearance, ſoon after the Full, on *Sept.* 12. 1714. In which ſeveral Riſings and Depreſſions may be ſeen, and the Tops of ſome of the Mountains ſomewhat diſtant, are expreſs'd by the little Spots.

These

Although then vaſt Mountains, when ſeen near at hand, ſeem to be very conſiderable Excreſcences of our Globe, yet ſince they are little, when compared to the Globe it ſelf, we may look upon our own, and all the reſt of the Globes, as if they were perfect Spheres, or at leaſt Spheroids. And finding them to be ſuch, let us next enquire what Reaſon there is to imagine this their Form to have been the *great* CREATOR's *Work*.

Theſe alone I conceive are the Mountains which the excellent *Hevelius* ſpeaks of in ſeveral Places of his *Selenography*, particularly in his Anſwer to *Bettinus*, and other *Peripateticks*, in Ch. 6. p. 143. who denied that Mountains could be in the *Moon*, as well as many other things diſcovered now by the Teleſcope.

CHAP.

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Chap. III.

The Univerſality and Uniformity of the Figure of the ſeveral Globes of the Univerſe is a Sign of their being the Work of GOD, not of Chance or Neceſſity.

WHEN we ſee divers Pieces of curious Device and Workmanſhip to bear the ſame Marks of Art, to have the ſame maſterly Strokes of Painting, Clockwork, Architecture, *&c.* we conclude with great Reaſon ſuch Pieces were made by the ſame skilful Hand. So when we ſee the ſame commodious Spherical Figure to be imparted to the Earth, and all the Heavenly Bodies, we have as good Reaſon to conclude them to be Pieces of the ſame Hand, Contrivances and Works of the ſame skilful Architect. For if the Univerſe had been a Work of *Chance*, all the ſeveral Globes would have been of ſeveral Forms, one of this, another of a quite different Figure: One ſquare, another multangular, another long, and another of another Shape. Or if all the ſeveral Globes had been a Work of *Neceſſity*, and their Figure had been owing to the natural Tendency, or Gravity of Matter, *viz.* that the ſelf-attracting Power of Matter did make all the Solids and Fluids of all the ſeveral Globes, as naturally run into a globoſe Form, as a Drop of Quickſilver doth: Yet ſtill we may demand, how came Matter by this ſo commodious a Power? What made it affect ſo proper a Form but the infinite CREATOR's *Fiat?*

But not to conteſt that Point, but granting *Gravity* to be congenial and coeval with *Matter*, without enquiring how it came by that Power, and allowing that every Globe of the Univerſe had its Form from the ſelf-attracting Power of its Matter, yet ſtill we have undeniable Marks of *final Cauſes*, of wiſe *Order*, and an over-ruling *Power* in the Caſe. For let us imagine our terraqueous Globe in its Chaotick-ſtate; all its Matter, every particle of it divided, and floating about, and ready, by its Self-attraction, to run together into its natural Form, that of a Globe: In this hurly-burly, this jumble of unguided Nature, made by Attraction only, a confuſed globoſe Maſs can be ſuppoſed to be formed; but without any Order, without that convenient Lodgment of its Parts, as the neceſſities of an habitable World require. But inſtead of any ſuch Signs of Diſorder, or of Nature's acting with an unguided Power, we have the clean contrary; all the Signals of a wiſe Contrivance, and excellent Art; as will appear in the following Chapter.

CHAP. IV.

The Terraqueous and other Globes appear to be the Work of GOD from the wiſe Diſpoſition of their Parts.

AS the Earth, and all the other Globes, would have been of various Forms, if they had been made by *Chance*, or would have been confuſed Maſſes, if made by *Neceſ-*

Neceſſity, according to the laſt Chapter: So in this I ſhall ſhew them to be the Work of a *wiſe* and a *kind Agent*, from the commodious Structure and Diſpoſition of their Parts, ſo far as we have any Knowledge of them. Thus the *Moon*, hath great Appearances of being no leſs commoniouſly, than the Earth, divided into Hills and Valleys (as I have ſet forth in the 2d Chapter;) into Dry-lands, and great Collections of Waters (*a*) and to be encompaſſed with an

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(*a*) That there are Seas, or great Collections of Waters in the *Moon*, is highly probable from the *Moon's Spots*, which plainly ſeem to be Water on theſe two Accounts, 1. Becauſe thoſe Spots appear to be in ſtrait and level long Planes, when viewed about the *Moon's* Quarters, or at ſuch times as one half of them are enlighten'd, the other half in darkneſs. In this Caſe, when we do not look directly upon the Planes, or ſee them wholly enlighten'd, but view them in a manner ſideways, their Surfaces look as the Sea doth, when we view it from the Shore, *viz.* a large level Plane: Only we may now and then diſcern a bright ſhining Part ſtanding a little out of an Atmoſphere as we are (*b*). So

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of the large Levels, which are, no doubt, certain Rocks or Iſlands in the midſt of thoſe Seas: 2. The Darkneſs of thoſe Spots, more than other Parts of the *Moon*, is an Argument they are Water, or ſome ſuch like Fluid, which imbibes the Sun's Rays more than harder Bodies, and doth not therefore ſo vigorouſly reflect them as they do. Accordingly about the *Moon*'s Quarters, when thoſe Spots, as I ſaid, have the Appearance of long Planes, we may obſerve their Edge to be a Kind of hazy Border, which grows darker and darker, as the Rays are more and more abſorbed.

But indeed hard Bodies, if they have ſmooth Surfaces, although they reflect ſtrongly to one Place, yet in other Places they are leſs viſible. Thus a Looking-glaſs, a Diamond, *&c.* reflect vigorouſly the Sun's Rays towards one Part, ſo as to dazle the Eyes; but in other Parts they appear of a dark, blackiſh hue. Which by the bye, is the Reaſon why Jewellers grind their Diamonds with many Sides and Angles, that their Luſtre may appear many ways. So Silver (as *Galilæo* obſerves, Dial. 1.) when boiled only in *Argol* and *Salt* appears as white as Snow; but wherever it is burniſhed, it becomes obſcure. And ſo he tells us, rightly enough, the *Moon* would become inviſible to us, if its Surface was not rough, but ſleek and ſmooth. See alſo *Hevelii Selenogr.* ch. 6. p. 151.

(*b*) That there is an *Atmoſphere* about the *Moon*, ſee Book 7. ch. 3. Note 1.

Jupiter, although at ſo great a Diſtance from us, hath manifeſtly, we ſee, his lighter and darker Parts; his Belts and Spots, darker than the reſt of his Disk. Theſe Mr. *Caſſini* (who longer viewed this Planet than any Body elſe) takes to be Canals containing ſome fluid Matter, or Water, that more weakly reflects the Sun's Rays, than the other Parts of the Planet do, and that they have ſome reſemblance with what happens here upon Earth. (*c*) *For if*, ſaith he, *one from on high, in the Heavens, ſhould ſee the Earth in ſome particular Situations, the Sea, which encompaſſeth the Earth, would appear very like the great ſouthern Belt that encompaſſeth the whole Globe of* Jupiter : *The* Mediterranean *Sea would make*

(*c*) *Nouvelles Decouvertes de Jupiter ; par M. Caſſini* in the *Memoires de Mathem. & de Phyſique* for *January*, *1692*.

an Appearance, not unlike thoſe Belts which are interrupted or broken, which we ſee in this Planet: The other Seas would make thoſe great black Spots, which never alter at all: The Continents and Iſles would ſeem like thoſe bright Spots that are alſo permanent: The Snows would make thoſe glittering Sparkles [Brilliants] *that from time to time diſappear: The Flux and Reflux of the Ocean, and thoſe great Inundations that happen ſometimes here, would occaſion other Spots to appear and diſappear: The Moon would reſemble one of* Jupiter's Satellites: *In fine, the Clouds of our Atmoſphere would reſemble thoſe broken interrupted Belts, and thoſe tranſitory Spots, which often change their Size and Figure, and have Motions of different Velocities.*

Thus that ingenious and curious Obſerver. According to whoſe, not improbable Opinion, this Planet *Ju-*

piter hath all its parts orderly placed, as is here upon Earth.

And ſo for the reſt of the Planets, whoſe Faces exhibit different Appearances, of brighter and darker parts, as *Mars* and *Venus* particularly do (*d*), it is highly probable that theſe may be ſuch a Diſtribution, ſuch an Allotment of Parts, as thoſe in *Jupiter*, and which are more plainly viſible in our own Globe.

Which brings me to ſpeak particularly of our own Globe, of which we have a nearer View, and can plainly ſee the Footſteps of divine Providence, in the wiſe and orderly Diſpoſition of all its parts; which are ſo diſtributed, ſo placed, as may beſt miniſter to the ſeveral Uſes and Conveniences of an habitable World. Thus for inſtance, the two grand

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(*d*) See Book 4. chap. 3.

parts, the Solids, and the Fluids of the terraqueous Globe, inſtead of being jumbled into one Maſs, are admirably parted, and as nicely laid in proper places. The Earth depoſited in uſeful *Strata*; ſome for the Service of the vegetable Kingdom; ſome for the generation and nouriſhment of Minerals and Metals; ſome for that of Stones and Foſſils; and ſome for the ſweetening and conveyance of the Waters. And here it is remarkable, and an Argument of a wiſe Deſign and Appointment, That all thoſe ſeveral *Strata*, or Beds, are lodged at proper and convenient Depths, and Diſtances from the Surface; *that* for Vegetables, the uppermoſt, for every Man to cultivate; and this divided into various Soils, and Moulds, for all the Varieties of Trees and Plants; thoſe *Strata* that contain the Minerals, Metals, and Foſſils, at ſuch Depths, as to be out of the way, when they may encumber, or hurt us; but may be come at by us, when we have occaſion for them. And as for thoſe *Strata* that convey the ſweet Waters (*e*) it is very remarkable, that they are ſo univerſal, in all, or moſt parts of the World; that they conſiſt of ſuch proper pervious Matter; that they remain ſo diſtinct from, and unmixed with the other *Strata*; and that they lie at ſuch due Depths, as either to break out into Fountains, or to be dug into, for Wells. But I ſhall not enlarge on theſe Matters, having ſpoken of them elſewhere.

And as this ſo commodious a Diſtribution of the Earth, ſo that of the Waters, is a manifeſt Demonſtration of the Concern of a *wiſe Agent*, although we ſhould aſcribe all that is poſſible to be aſcribed, to the Ne-

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(*e*) See *Phyſico-Theol.* Book 3. ch. 2.

ceſſities of Nature in the Formation of the World. For the Waters, if we obſerve them well, are accurately diſperſed, and lodged about the World, for the proper Offices thereof, in Seas, in Lakes, in Rivers, and in Fountains, to ſatisfy the Thirſt of Animals, to afford them ſome part of their Food, and to miniſter abundant Supplies of Vapours for the Clouds, the Rains, and Winds: Which Supplies muſt either have failed, or been too abundant, or have been attended with ſome or other great Inconvenience, without ſuch a commodious intermixture of the Land and Waters.

This Συναγωγὴ, as the LXX tranſlate it, this orderly *gathering together* of the Waters, is implied in *Moſes*'s Relation of this Branch of the Creation, *Gen.* i. 9. *And God ſaid, Let the Waters under the Heaven be gathered together unto one Place.* Where the *Hebrew* Word *Ikkavu*, denotes a regular and orderly *gathering of the Waters*, as if their Allotment had been made, their Receptacles had been *marked out by a Rule, or a Plumb-line*, by the CREATOR's *Fiat*.

Thus it is demonſtratively plain, that the Earth and Waters were laid by a wiſe Hand; and therefore whatever concern Nature might have in giving a Sphærical Figure to our Globe, yet was the CREATOR the principal *Agent*, the grand *Manager* of the Matter.

CHAP. V.

The Convenience and Neceſſity of a Sphærical Figure to the Good of the Globes, is an Argument they were the Work of GOD.

BESIDES the orderly and commodious placing the Parts of the ſeveral Globes, ſpoken of in the laſt Chapter, there are ſtill other Reaſons to aſcribe the Sphæricity of our own and the other Globes to a *wiſe Agent*. For beſides that this Figure is the moſt agreeable to a World, as being the moſt capacious; and the moſt agreeable to a Maſs in Motion, as being at a due Diſtance from the Center of Motion and Gravity; ſo without this Figure there could have been no ſuch comfortable, and agreeable Alternations of Day and Night, of Heat and Cold, as now there are, but ſome parts muſt have been, for too long a time, skreened from the kindly Approaches of the Sun and Moon, and conſequently have lain under too long and uncomfortable a Darkneſs, and been chilled with miſerable Cold. And as to our own Globe, the Winds could not have given thoſe kindly, and ſalutiferous Agitations to the Air, as they do, but they muſt have been too much retarded, if not wholly ſtopp'd by the exorbitant Angles, and Jettings-out of other Figures. And laſtly, the Waters, which I ſhewed to be well intermixed with Dry-Land, would have had intolerable Confluences; one part too much, another none at all; no Vapours, no Fountains, no Rivers: So that inſtead of an habitable, well-ſtocked

World, far the greateſt part would have been either a Deſart, or an unneceſſary Confluence of Water.

Thus having made it evident, that particularly our own Globe received its Figure by the Direction of the infinitely wiſe *Architect* of all things: We have Reaſon, had we none beſides, to conclude the ſame of all the reſt of the Globes of the Univerſe, inaſmuch as they agree with ours in other Things as well as in their Figure, ſo far as we have any knowledge of them, and their State. Thus the Planets of the Solar Syſteme, have their Light from the Sun as well as we; they turn round on their own Axes, and revolve round the Sun, and conſequently have their Days and Nights, their Summers and Winters, as well as we; they have their Hills and Vallies, as I ſaid, their Land and Waters, by all the Signs that may be, as well as we; and therefore agreeing with our Globe in ſo many of thoſe very Things, wherein their Figure is concerned, had we none of thoſe Reaſons I have already mentioned, there would however be great Reaſon to preſume the ſame Thing of them, as of our Earth, *viz.* that they received their Figure from the ſame wiſe CREATOR, and that (were we near enough to behold them) they have as manifeſt Signals of it as we have.

BOOK

BOOK VI.

OF THE

Attraction or *Gravity*

OF THE

Terraqueous, and the other Globes.

CHAP. I.

The Uſefulneſs of Attraction *in the Production and Preſervation of the Figure of the Earth, and the Deſcent of heavy Bodies.*

HAVING in the two laſt Books treated of the Motions and Figure of the Globes, I ſhall in this conſider their *Gravity* or *Attraction*, which according to the modern Philoſophy (which hath great Reaſon and Probability on its Side) hath a great Agency in both theſe Matters, both in effecting and preſerving the Figure of the Globes, and governing their Motion.

As to the Agency of the natural Attraction of Matter, in the production and preſervation of a ſphærical Figure, as that of the ſeveral Globes is, beſides what hath been before ſuppoſed, it may be collected from the ſphærical Figure which moſt Fluids take, when there is no Obſtacle to hinder their doing ſo. Thus I have ſaid *Quickſilver* manifeſtly doth, eſpecially in ſmall Drops or Quantities; in which Caſe their own ſelf-attracting Power, is equal to, or exceeds that of the Earth: So doth Lead, and other Metals, when in fluxion (*a*); ſo doth Water,

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(*a*) This is very manifeſt from the making of *Shot* ter, Oyl, and in ſhort all Liquids, which run nearly into a ſphærical Form, when hung on a ſmall Surface; as at the Point of a Pin; or into an hemiſphærical Figure, on a broader Surface; their Self-attraction cauſing the former, as that of the Earth, and the Surface on which they lye, doth the latter. Theſe Phænomena have indeed been aſcribed to divers Cauſes, moſt of them probable enough, except the Preſſure of the incumbent Air: But this is manifeſtly not the true Cauſe, by Reaſon the Caſe is the very ſame in the *Air-Pump* (when the Preſſure is taken off) as in the free Air; and

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Shot. The Way of doing which, is by running the melted Lead through a Ladle full of Holes into cold Water. In doing which they take Care, their Lead be not too hot, becauſe the Globules would then fly to pieces; nor too cold, becauſe it would then be long and have Tails; but in a due Temper it turns round. They put *Orpiment* into their Lead, when they melt and prepare it for Shot.

therefore ſome other Cauſe is to be found: And what more probable, or ſo probable, as this of *Gravity* or *Attraction*, which manifeſtly exerts itſelf in ſome, and is highly probable in all material Things? (*b*) In the Earth it ſelf there is manifeſtly ſuch a Thing as *Gravity*, which might as well be the natural Cauſe of the Sphæricity of our Globe, as it is in that of leſſer Maſſes, but then, as I demonſtrated in the laſt Book, it is alſo evident, that an over-ruling Power, and a wiſe Providence, not only gave Matter this gravitating Power, but guided and managed it in the Formation of the World.

And now upon Suppoſition that *Gravity* had any thing to do in the

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(*b*) For the Proof of this I ſhall refer to Sir *Iſaac Newton's Opticks*, Quæſt. 31. of the ſecond Edition, and in his *Principia* in many Places, particularly L. 3. Prop. 5, 6, 7.

production of this ſphærical Figure I am ſpeaking of; the ſame it muſt have alſo in the conſervation of that Figure. For the ſame Power it exerted at firſt, it retains ſtill; which is as neceſſary ſtill to the preventing and obviating all extravagant Excurſions, and Deviations from that Figure, which may happen through extraordinary Commotions and Convulſions in any of the Globes; ſuch as Earthquakes are, and other ſuch like furious Concuſſions and Emotions that ſometimes befall our own Globe.

But leaving theſe conjectural Matters, let us come to a more evident Benefit of *Gravity*, and that is the natural Tendency of all Bodies to the Center of the Globe: This is very manifeſt in our own Globe. For whatſoever the Decays are among earthly Things, howſoever their Forms are changed, yet their

Matter remaineth entire, and returneth again to its grand Parent the Earth: Or to put it in *Solomon's* Words, *Eccl.* i. 4 *One Generation paſſeth away, and another Generation cometh: but the Earth abideth for ever.*

And an admirable Proviſion this is for the Perpetuity of the Globe, and to continue the State and Habitability thereof throughout all Ages, which would otherwiſe waſte and decay, or run into the moſt irreparable and pernicious Diſorders.

Chap. II.

The Guard which Gravity affords againſt the Centrifugal Force of the ſeveral Globes.

UPON a Suppoſition that every of the Globes revolves round its own Axis (which I have ſufficiently proved in the fourth Book) we ſhall find, beſides the Benefits already ſpecified, another very great Uſe of Gravity, to the Good, yea the very Exiſtence of our own and other Globes, and that is the Preſervation of their Integrity againſt the *Centrifugal Force* of this their Revolution, or diurnal Motion. For without ſuch a Band, as Gravity, to keep their parts together, the whirling about of thoſe Globes would ſhatter them into pieces, and diſſipate them abroad into the circumambient Space. Thus muſt it needs befall our own Globe, which whirls about at the rate of above 1000 Miles an Hour (*a*), and is compoſed of Earth and Water, Materials of much too looſe a Texture, to prevent the diſſipation, which the *Centrifugal Force* of ſuch a Rotation muſt neceſſarily occaſion, about the Æquatorial Parts; a Rotation that would as eaſily throw off the Parts of the Earth, eſpecially the Waters, as the whirling round of a Wheel or a Globe, would the looſe Duſt and Water lodged thereon. But by reaſon the *Gravitating Power* exceeds the *Centrifugal*

(*a*) The Diameter of the Earth being 7967,7 Miles, according to B. 1. Ch. 2. Note 1. the Ambit thereof is 25031,4 Miles, which being divided into 24 Hours, makes the Revolution to be at the Rate of about 1043 Miles an Hour.

fugal as 2174 exceeds 7.54064 (*b*) that is above 288 times, therefore all parts lye quiet and ſecure in their reſpective places, and enjoy all the Benefits, which I ſhewed do accompany this Motion, without any Diſturbance from it.

Thus is our own Globe guarded by its *Gravity* againſt the *Centrifugal Force* of its Rotation. But this is far more remarkable in ſome of the other Globes. Thus particularly in the Sun, whoſe Ambit is, 2582873 Miles, and whirls round once in about 25 $\frac{1}{4}$ Days, and conſequently doth revolve at the rate of 4262 Miles an Hour (*c*), which is above four

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(*b*) This is the Proportion or nearly ſo, of the *Gravitating*, to the *Centrifugal*, *Force* of the Earth under the Equator, as may be computed from Sir *Iſaac Newton's Princip.* L. 3. Prop. 19.

(*c*) The Sun's Diameter being 822148 Miles, the Numbers here aſſigned will naturally follow.

As to the Sun's *Gravity* or *Attractive Power*, it four times as faſt as the Earth; this in a little time would endanger its Diſſipation without ſuch a Proviſion as *Gravity* is.

But what is this to the *Centrifugal Force* of *Jupiter*? whoſe Bulk far exceeds our terraqueous Ball, and whoſe Rotation is performed in leſs than half the Time. But from a Computation of Particulars, we ſhall better eſtimate the Matter. The Diameter of *Jupiter* being 120653 Miles, its Circumference is 379043 Miles: Which revolving round in leſs than ten Hours, is at the rate of 38159 (*d*) Miles an Hour at its Æquator. And if the Denſity of every

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it is (by the Calculation of my Friend the acute and learned Dr. *Halley*) to the Sun's *Centrifugal Force*, as 47000 to 1: The Method for finding which, ſee in Note *e*.

(*d*) *Jupiter*'s Ambit being 379043 Miles, and his Revolution 9 h. 56′ or 596 Minutes; the Revory Planet be proportional to its Diſtance from the Sun, as is now with great Reaſon imagined, that is, if thoſe Planets neareſt the Sun, as *Mercury* and *Venus* are proportionably denſer than thoſe more remote, as *Jupiter* and *Saturn*; then is the Globe of *Jupiter* of a laxer Texture than ours is, and in ſo much the greater Danger therefore of being whirl'd to pieces by ſo rapid a Motion, as that Planet manifeſtly hath, were not its parts kept cloſe together, and ſedate, by ſuch a Band as *Gravity* (*e*) is.

Revolution in an Hour is by the Logarithms thus.

596 minutes	2.7752463
379043 miles	5.5786884
: : 60 minutes	1.7781513
	7.3568397
38159 miles	4.5815934

(*e*) The Proportion of *Jupiter*'s, or any other *Planet*'s, or the *Sun*'s *Gravity*, to their *Centrifugal*

Force may be computed from the moſt ſagacious Sir *Iſaac Newton's Princip.* L. 3. Prop. 8. & 19. But the before-commended *Savilian Profeſſor*, ſuggeſted to me this eaſier, and quicker Rule, for ſuch Planets as have *Satellites*, *viz. The Proportion of the Centrifugal to the Centripetal Force, or Gravity of any Planet at its Surface, is compounded of the Ratio which the Cube of the Semidiameter of the Planet hath to the Cube of the Diſtance of any of its Satellites from the Center of that Planet; and the Ratio which the Square of the Satellites periodick Time hath to the Square of the periodick Time of the Planet's Revolution.* Thus for inſtance, the Diſtance of *Jupiter*'s outermoſt Satellite being 253 Semidiameters of *Jupiter*, and its Period 16 days, 16 hours, 32 minutes, or 24032 minutes, and *Jupiter*'s Revolution 526 minutes; we ſhall find the Gravity in *Jupiter*'s Surface to be to his *Centrifugal Force* in his Equator, as 1 to *9,96*.

CHAP. III.

Of the Power and Uſefulneſs of Gravity to retain the Planets in their Orbits.

FOR a Concluſion of this ſixth Book, I ſhall take Notice of one more remarkable Benefit of *Gravity*, which is grounded upon the Suppoſition of the Truth of the *Newtonian Philoſophy*; which hath ſo good Grounds, and great Reaſon, I might ſay Demonſtrations on its Side, particularly in this Matter, that admitting of it here, we ſhall diſcover another admirable Work of the Creation, and that is, the preventing the Evagation of the Planets, and the accurate retaining them within the due Bounds of their Orbits. That this is done by *Gravity*, and that *Gravity* and *Motion* ſolve in the moſt complete Manner, all the Phænomena of the planetary Motions both Primary and Secondary, is abundantly made out by the wonderful Sagacity of the great Sir *Iſaac Newton*; as may be ſeen in his *Principia*.

But before I come to the particular Agency of *Gravity*, it will be neceſſary to premiſe ſomething concerning its Nature, and ſome of its Properties, *viz.* That *Gravity* is not terminated at the Surface, but reaches to the very Center, and is extended to immenſe Diſtances all round the Centers of all the Globes: By which Means, the cœleſtial Bodies are enabled to have Syſtems of leſſer Globes revolving about them. For had the Force of *Gravity* determined at, or near the Surface (as it might have done, if intended only for the Conſervation of the Globes) in this Caſe, all the Bodies that were put in Motion, and that were to paſs at ſome Diſtance from them, would move on in a ſtrait, not curved Line, and be loſt in the great Abyſs of Space. But the all-wiſe CREATOR hath, in his firſt Production of Matter, beſtowed upon it ſuch a Property, as that every Particle thereof hath a Tendency towards every other Particle. From whence it comes to paſs that every Body hath a *Gravitating Power* according to the ſolid Content, or real Quantity of its Matter, and not according to its Superficies, or Extenſion.

And this *Gravity* of all Bodies is obſerved, manifeſtly to decreaſe in proportion of the Square of their Diſtances reciprocally; that is, at twice their Diſtance the Force is but one fourth of what it was at a ſingle diſtance; and but a ninth, at thrice the diſtance, *&c.*

That this is ſo, is abundantly proved by the laſt commended Author; who by eſtabliſhing this one Principle in Philoſophy, hath fully explain'd the Syſteme of the World, ſo far as relates to us, and to all the reſt of the Planets, that regard the Sun as a Center, both Primary and Secondary.

What the Cauſe of *Gravity* is, Sir *Iſaac Newton* doth not pretend to aſſign, his Deſign being not to engage himſelf in framing *Hypotheſes*, but to explain the *Phænomena* by *Experiments* only, and to raiſe his noble Superſtructure upon them. And therefore, although the Matters of Fact, and the final Cauſes are evident, I will not venture to ſay how it comes to paſs, that Bodies act at ſuch immenſe Diſtances upon one another; but chuſe rather to acquieſce in adoring the Wiſdom and Power of the GREAT AUTHOR of all Things, who hath inſpirited the Materials of which the World conſiſts, with ſuch an active Quality, as ſerves not only to preſerve the Globes themſelves entire, but to enable them to revolve about their luminous Center (from whence they have their Light and Heat) in Orbs that are the moſt commodious, and alſo fixt and permanent.

Having thus premiſed what was neceſſary for the underſtanding the Nature and Properties of *Gravity*, I ſhall proceed to conſider its Agency in the planetary Motions. And here we have divers Things, which plainly demonſtrate theſe Motions to be no Matters of *Chance*, but the Works of an infinitely *Kind*, as well as *Omnipotent*, and *Allwiſe Agent*.

I have already in Book 4. Ch. 2. taken Notice, of the Motion of the Planets, being made, not in Lines tending from the Center to the Circumference, or very obliquely thereto, but acroſs, or nearly perpendicular to the *Radii*. Alſo that the Motions, and Orbits of the Planets, do not tend contrary ways, or interfere with one another. That therefore which I ſhall ſpeak of here, concerning the planetary Motions being the Work of God, will be only ſo far as Gravity is therein concerned. And,

1. It was a very notable proviſion to prevent the Evagation of the Planets, and to keep them within their due and proper Bounds, to bridle and detain them with Gravity, as with ſo many Reins and Bridles. For as the natural Tendency of all impreſt Motion is in ſtrait Lines, ſo when Motion was given to the Planets,

nets, this Motion (altho' as I ſaid it was artificially made, perpendicularly to the *Radii*, yet) would carry them quite away in their Tangents, ſo that they would never return again. But being thus detain'd by Gravity, another admirable proviſion is, that, 2. They are moved in Orbs: Which Orbs are formed of a Motion compounded of this Rectilinear Impulſe, impreſt upon the Planets, and the Tendency of their Gravity to their Centers. In which Motion a third Thing very remarkable is, That the Impulſe or Velocity which is imparted by the *firſt Mover* to every Planet, and the Gravity of each Planet, are ſo nearly equal to what is required to make a Body deſcribe a Circle, that the Orbits of the Planets are not very Eccentrical, but nearly Circular. As is particularly remarkable in *Venus*, and the *Earth*; and more eſpecially in the whole Syſteme of *Jupiter's Satellites.* And an admirable Work this is. For ſhould the Velocity of any Planet be double to what would make it move in a Circle, the Planet would go away *in infinitum*, without ever returning again in any Orb whatſoever. Or ſhould one half of the Velocity be taken away, the Planet would deſcend obliquely towards the Sun, until it became four times nearer the Sun than before; and then aſcend again to its former place, deſcribing a very eccentrical Orb. And by aſcending and deſcending alternately, it would be heated ſixteen times more at one time than another. Which uneven Heat would make the Planet unfit for Habitation. And the ſame Thing would happen, if the Determination of its Motion ſhould be altered, ſo as to become very oblique to the *Radius*, drawn from the Planet to the Sun,

Sun. But theſe Things being accurately adjuſted, and contempered, make the whole Syſteme to be a Work of incomparable Convenience and Beauty; a Work the beſt contrived for the Benefit of the World's Inhabitants, and to ſet forth the Curioſity and Skill of the infinite Workman.

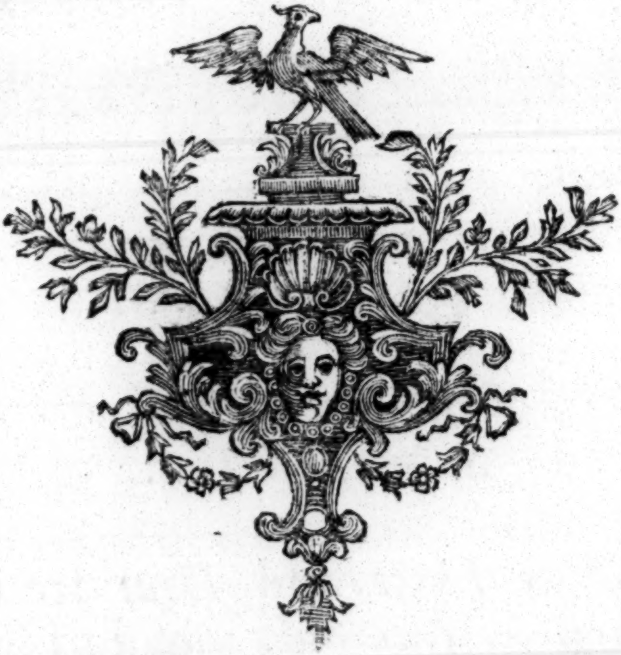
It is manifeſt therefore that the Syſteme of the Planets is not to be reckon'd a Matter of *Chance*, or a Thing owing to a *Neceſſity of Nature*, but the Work of a kind and wiſe Agent. And that this is ſo, will be farther manifeſt from the Caſe of *Comets*, whoſe Motions, Directions and Orbs being utterly different from thoſe of the Planets, demonſtrate the planetary Syſteme to have been modelled by *Counſel*, and not by a *Neceſſity of Nature*, or left to *Chance*. For as for the Motion of *Comets*, it is ſo far from being always the ſame

way,

way, that they move ſometimes contrary to one another. And as for their Planes and Directions, they lie every way. And as for their Orbs, they are exceedingly eccentrical. And by the bye, this Eccentricity is an admirable Contrivance of the CREATOR, to prevent the Comets from diſturbing either the Planets, or one another, by their mutual Attractions. For by this Means, they have a large and ſufficient room to revolve in; and by aſcending to very great heights, above the Syſteme of the Planets, and ſpending almoſt all their Time in the remote Regions of the Univerſe, at vaſt Diſtances both from the Planets, and from one another, they do not incommode either the Planets, or themſelves; as otherwiſe they would have done, ſhould they have moved in the ſame Plane with the Planets. For had they done ſo, they would have been apt ſometimes to have come too near the Planets, and have diſturb'd their Motions, and perhaps have daſhed upon them alſo. But all theſe Circumſtances are ſo well adjuſted, and ſo wiſely regulated by the Divine Providence, that the Syſteme could not have been better contrived, either for Convenience or Beauty.

And now upon this highly probable, I may ſay phyſically certain, Theory, of Gravity acting in the Motion of the Globes, we have another exquiſite Nicety in the Works of the Creation, that juſtly deſerves the greateſt admiration and praiſe; that among ſo many immenſe moving Maſſes, they ſhould all obſerve their due Bounds, keep the moſt proper Paths appointed for their Convenience and Good, and at all Times anſwer the great Ends to which they miniſter in the Creation. Particularly that the *habitable Globes* ſhould always remain at ſuch due Diſtances, and move in ſuch proper Orbits, as are beſt for them. And that the Comets too, ſhould at the ſame Time paſs in paths utterly different, but yet ſuch in all probability, as may render them alſo of very great Uſe to ſome or other parts of the World; whether we look upon them as places of Torment (as hath been ſaid) or Bodies appointed for the Refreſhment and Recruit of the Sun, or any of his Planets, as Sir *Iſaac Newton* conjectureth in his *Princip.* L. 3. Prop. 41 *&* 42.

And now from the Conſideration of what I have ſhewn in this ſixth Book, to be either highly probable, or very certain, concerning *Gravity*, we have another manifeſt Demonſtration of the infinite CREATOR's Wiſdom and Care, and another cogent Argument to excite the higheſt Veneration and Praiſe in his Creatures.



BOOK VII.

Of the PROVISION made for LIGHT and HEAT Throughout the UNIVERSE.

CHAP. I.

Of the Light and Heat of the Fixt Stars and Sun.

AS *Light* and *Heat* are two of the moſt uſeful Things in the Univerſe, ſo the infinitely wiſe and kind CREATOR hath made an excellent Proviſion for theſe Things; in all probability, for every Globe throughout the Univerſe, but particularly for thoſe of our own Syſteme. For it is very manifeſt, that every Globe we ſee, doth ſhine with its own native, or with borrowed Light. Even all thoſe immenſe Bodies at the greateſt Diſtance from us, the Fixt Stars, which I have before ſaid, are probably ſo many Suns, it is Light they manifeſtly dart as far as to our ſo diſtant Globe, as well as what they emit for the enlightening, warming, and cheriſhing their own reſpective Planets.

But I ſhall forbear to launch out into thoſe conjectural Matters, and ſhall come nearer home, into our own Syſteme, where we have enough to entertain our Eye, to captivate our Thoughts, and to excite our higheſt Admiration of theſe magnificent Works of God; whether we ſurvey the great Fountain it ſelf of our

Light and Heat, the Sun; its due Poſition, and its wonderful Uſe to its Planets; and the incomparable Proviſions that are made to ſupply its Abſence and greater Diſtances from them.

And in the firſt place, as to the Sun it ſelf; what Power is there that the moſt extravagant Fancy can imagine to it ſelf, that could ever be able to make ſo prodigious a Maſs of Fire as the Sun is, but only the *Power of God's Almighty Hand!* A Body of ſo immenſe a Bulk, as I have ſhewn it is, and of ſuch an exceſſive Heat, that no greater a Number of its Rays, than what fall within the compaſs of a two, or three Inch Burning-Glaſs, ſhall actually burn; and what fall within the compaſs of not many Feet, ſhall far exceed the ſtrongeſt culinary Fire in the Earth: As is manifeſt from its almoſt inſtantaneous burning and vitrifying the moſt obdurate, incombuſtible Bodies, ſuch as not only green Wood, and white Bodies, but alſo Stones, Bricks, Metals, yea Gold it ſelf (the hardeſt of all Metals to be wrought upon by Fire) which yet is melted down in a few Minutes (*a*).

Thus

(*a*) The famous *Burning-Concave* at *Lyons*, of 30 Inches Diameter, and others in *France* and *Germany*, of greater breadths, have been celebrated for their Feats in burning, calcining and vitrifying, both metallick and other Bodies. But I queſtion whether any of them have come up to the Burning-Inſtrument contrived by, and made for Sir *Iſaac Newton*, and by him preſented to the *Royal-Society*. It conſiſts of 7 concave foiled Glaſſes, each of them 12 Inches Diameter, which are all ſo placed, as to have their *Foci* concur in one Point. By which Means the Heat is ſo increaſed, as in a ſurprizing Manner, to perform the Feats here mentioned, and many others ſurpaſſing them.

Having mentioned theſe *Burning-Concaves*, it may be of uſe on ſeveral Occaſions, and particularly for the cheap trying of Experiments, to take Notice of what was related to me by a Perſon of very high Quality: Who doing me the Honour to talk with me about ſuch *Concaves*, told me, that in *Germany* one Mr. *Czhernhauſen*, a *Sileſian* Gentleman, made divers

Thus the *infinite Power and Wiſdom of GOD*, appear in the appointment, and make of that immenſe Body of Fire, the Sun; a Maſs wonderful, and worthy of its Maker, whether we conſider its immenſity, its exceſſive Heat, or its abſolute neceſſity, and great Uſe to us, and to all the reſt of its Syſteme. But we ſhall find yet farther Evidences of the great CREATOR's Work in the following Chapter.

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divers very large *Concaves with Paſte-board*; which were covered over with a kind of Paſte or Foil, that ſtrongly reflected the Sun's Rays. But what their Power was, he did not ſee.

Chap. II.

Of the due Poſition and Diſtance of the Sun and its Planets.

As the infinite Power and Wiſdom of God appears in the Appointment and Make of the Sun, according to the preceding Chapter; ſo in this I ſhall demonſtrate the ſame, from the due Poſition of the Sun among his Planets, and his due Diſtance from each of them.

Now here we may take it for granted, that the Sun is the Fountain of the Light and Heat of all the Planets, not only of the Earth, but of the other Planets, that move either about the Sun, or the Earth. But whether the Sun be placed in the

Center of its Syſteme, or the Earth be ſo, is of no great Conſequence here to enquire. But I have all along ſuppoſed the former to be the moſt probable Hypotheſis, and it ſeems to be ſtill more ſo, from the Conſideration we are now upon, concerning the Community of its Light and Heat to all the Planets. For ſince it is manifeſt, that what Light and Heat the Planets have, they receive from the Sun, it is far more likely that this their Fountain of Light, and Heat, is placed in the common Center of them, and that they move round about it, rather than it about them.

But be it ſo, or not ſo, it is however very certain, that all the Planets are placed at ſuch a due, and proper Diſtance, from the Sun, that they receive the beneficial Rays thereof, in a due manner and proportion. There is no great Reaſon to doubt of this, among the Planets that are at greater or leſſer Diſtances from the Sun than we, becauſe we find a noble and ſolemn Apparatus, anſwerable to their Diſtances from the Sun; which I intend to ſpeak of hereafter. But as for our own terraqueous Globe, we have ſufficient Signals of the great Care and Counſel, that have been uſed in the due Poſition, and Diſtance thereof from the Sun. For as to its Poſition to the Sun, I have heretofore ſhewn, that by the Inclination of its Axis, and its diurnal and periodical Revolutions, all parts have a due Share of Light and Heat. And as for its Diſtance, it is ſuch, as not only prevents the Danger of its interfering with the other Globes, as I have formerly obſerved, but alſo it is duly adjuſted to the Denſity of the Earth and Waters, and to the Make and Temper of our Bodies, and of all other Things here below. Had we been much nearer the Sun, our World would have been burnt up, and waſted; the Waters, in the firſt place, would have all been turned into Vapours, and dried up; Vegetation have ſoon ceaſed, and all Things would have ſoon been waſted, if not burnt and conſumed. Or had we been not at ſo very great a Diſtance, but only a little nearer the Sun, than now we are, as ſuppoſe a few thouſand of Miles, ſtill the Heat would be as the ſquare of the (*a*) diſtance; and conſequently too great, if not for the Polar, yet for the Æquatorial parts. And on the contrary, had we been ſet at a greater Diſtance from the Sun, ſo would the Sun's Heat have been abated, in proportion to the Square of that Diſtance. And in this Caſe if the Diſtance had been

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(*a*) *Newton. Princip.* p. 466.

very great, we and all Things muſt have been perpetually frozen up; or if it had been not ſo great, the World would have ſuffered by Cold, the Polar at leaſt, if the Æquatorial parts could have eſcaped.

And in this Caſe, when our Globe ſhould thus be parched up with everlaſting Heat, or be everlaſtingly frozen with exceſſive Cold; inſtead of an habitable, pleaſant, and comfortable World, it muſt become a Deſart, a place of irkſomneſs, miſery, and everlaſting puniſhment. But the great CREATOR having ſo wiſely, and indulgently, ordered the Diſtance between the Earth and Sun, the Sun's Light and Heat are incomparably accommodated to the State and Temper of all Things here below, and our World is well fitted for Habitation, well provided with every Thing that may miniſter to the ſupport, the comfort, and pleaſure of its Inhabitants. By thoſe indulgent Rays, all Things are enlightened, and we, and all the reſt of the Animal Kingdom, are enabled to diſpatch our Buſineſs, to ſeek and provide our Food, and to paſs from place to place, as our occaſions or pleaſure lead us. By its cheriſhing Beams all Things are warmed and comforted, Vapours, in ſome Meaſure, made to riſe for the forming of Clouds and Rain; Trees and Plants are enabled thereby to put on their Verdure and Gaiety, and to yield us the benefit and pleaſure of their Grain and Fruit. By the preſence of this great Fountain of Light and Heat, we and even Nature too, is awake and excited; and by its abſence, grows torpid and dull: Its abſence by Night, diſpoſes us to reſt and ſleep; and even Vegetables too ſhut up their Flowers then (*b*),

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(*b*) See my *Phyſico-Theol.* B. 10. N. 14.

and in a manner betake themſelves to reſt: And its Abſence in Winter, how doth it change the whole Face of Nature, diveſt Vegetables of their gay Attire, force Animals to places of Shelter and Safeguard, and give an Aſpect of Melancholy and Horrour to all Things!

Thus it is manifeſt how wiſely and indulgently the great CREATOR hath provided for the Good of our Planet, by ſo critically adjuſting its Poſition to, and its Diſtance from the Sun, to the State and Temper of it, and all Things thereon. And although the reſt of the Planets, encompaſſing the Sun, are ſome of them nearer to, ſome of them farther from it, yet there is no great Queſtion to be made, but the ſame wiſe Contriver hath made as good a proviſion for them as for us, either by contempering their Denſity to their Diſtance from the Sun, or by ſome other the wiſeſt and beſt Courſe; as we have very juſt Reaſon to ſuſpect, from that grand and ſolemn Apparatus I ſhall ſpeak of, of Secondary Planets. Which leads me to conſider the Proviſions made for the Supply of the Sun's Abſence, and its greater Diſtance.

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Chap. III.

The Neceſſity of Light, and the Proviſion for it by the Atmoſphere.

BEFORE I come to the other Planets, it will be convenient to conſider how the Sun's Abſence is ſupplied here upon the Earth, as alſo, probably, how it is ſupplied in her concomitant the Moon.

And firſt as to the Earth. Of ſuch abſolute Neceſſity is Light (not to mention Heat) that our World could not well be in the leaſt utterly without it, becauſe if there ſhould be utter, abſolute Darkneſs (beſides the great inconveniences it might bring to Vegetables, Minerals, and every other ſuch like part of the Creation, beſides this I ſay) it would certainly put Animals under an abſolute incapacity of performing their moſt neceſſary Buſineſs, and acting in that Office which the divine Providence hath appointed them, although of greateſt Uſe to themſelves, or the reſt of the World. Men, for inſtance, whoſe Buſineſs and Occaſions oftentimes neceſſitate them to borrow a part of the Night; and all other Animals, particularly ſuch whoſe Safety or Temper, or Conſtitution of Parts (as of their Eye for inſtance, or ſome other Parts) confine them to their Dens, and Places of Retirement, and reſt by Day, and are therefore in Courſe compelled to ſeek their Food, and wander about on their moſt neceſſary Occaſions of Life by Night, all theſe, I ſay, would at once be cut off from one of the grand Benefits of Life, from acting that part they bear in the Creation, during ſuch Time as they ſhould be put into abſolute Darkneſs. But to prevent this the infinitely wiſe *Contriver* of the World hath made divers admirable Proviſions, both in our own, and the other Planets too. One proviſion which he hath made in our own Globe, and I may add that of the Moon alſo, is by encompaſſing both with an Atmoſphere (*a*), which, among other grand Uſes, miniſters very much to the propagation of

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(*a*) Mr. *Huygens* in his *Coſmotheor*. p. 115. concludes the Moon to have no Air or Atmoſphere, becauſe we ſee its Limb ſo clearly and accurately defined, and becauſe he thought there are no Seas or Rivers in the Moon. But he was miſtaken both in his Concluſion and part of his Premiſſes. For in the Solar Eclipſe *May* 1. 1706. which in *Switzerland* was Total, they could manifeſtly perceive the Moon's Atmoſphere, as may be ſeen in the Accounts given in *Philoſ. Tranſ.* N° 306. And ſince that, in the laſt Total Eclipſe of the Sun, *April* 22. 1715. the *Moon's Atmoſphere* was very diſcernible, appearing in the Form of a curious Ring of Vapours encompaſſing the *Moon* all the Time of Total Darkneſs. Of which ſee the Accounts, in the *Philoſ. Tranſ.* and Mr. *Whiſton*'s.

Light, partly by reflecting the Rays of Light to our Eye, and partly refracting them, ſo as to make them viſible and uſeful to us, when otherwiſe they would not appear. Hence that Whiteneſs and Brightneſs (*b*) obſervable in the Air by Day; and hence the Twy-light, when the Sun is hidden under the Horizon. The like to which is obſervable in the Moon alſo, in that Secondary, ruſty Light which is ſeen in her Eclipſes, and before and after her Quarters.

(*b*) See *Phyſico-Theol.* B. 1. Ch. 1. Note 12.

Chap. IV.

The great Uſefulneſs of the Moon, *and the mutual beneficial Returns which the Globes make to one another.*

HAVING ſhewn the abſolute Neceſſity of Light, and the Supply thereof by the Atmoſpheres; let us next ſpeak of the principal proviſion made for that, and for ſupplying the Sun's Abſence, and that is by the *Moon* and *Stars*, which as *Moſes* ſaith (*a*) *rule the Night*, as the *greater Light*, the Sun, doth *rule the Day*. What Influences theſe

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(*a*) Gen. i. 16.

cœleſtial Bodies may have here below, in the Bodies of Men, and other Animals, or among Vegetables, Foſſils, or in any of the grand Works of Nature, is hard to determine, although vainly pretended unto by the judicial Aſtrologers: But yet ſome Things there are, whoſe Periods and Criſes ſo ſtrictly obſerve the Courſes of the Sun, eſpecially of the Moon, that, on the other Hand, it is hard to deny the Influences of theſe Bodies here below. The *Tides* particularly have all along ſo conſtantly obſerved the Courſes of the Moon, that in all Ages they have been ſuſpected to be cauſed and governed by that Planet: And if the Stories of *Pliny* (*b*), *Ariſtotle*, and others of the Ancients be true, it is by her Influence, that the Bodies of Oyſters and other Shell-fiſh are increaſed and

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(*b*) *Plin. Nat. Hiſt.* l. 2. c. 41, 98, 99, 101.

diminiſhed; that the Maſs of Man's Blood is ſo alſo; that the Humours are reſolved and attracted; that the dead Bodies of Beaſts are corrupted; that all Animals expire at the Time of Ebb, particularly Man; that the Sea purgeth it ſelf of Filth every Full-moon, which gave Occaſion to the Fable of the Sun's having his Stable about *Meſſina* and *Milazzo*; and divers other ſuch like Conceits, which thoſe Authors name, too many, and too improbable, to deſerve to be reckon'd up in this place.

But whatever influences the Moon may have upon Things here below, whatever her Concern may be in any Tranſaction of Nature, or any other Office of the Creation, it is however very certain that her *Light*, *Eclipſes*, *Monthly Revolutions*, and *Latitude*, or Vagations towards our Poles, are of great Uſe to us.

By her *Light*, to which I may add that of the *Stars*, we and the reſt of the Creatures are able to protract our Day at pleaſure, to go hither and thither, as our Occaſions call, and to diſpatch many of our Affairs by Night, or to betake our ſelves to Repoſe and Reſt, to which, according to *Pliny* (*c*), the Moon doth naturally incline us.

As to the *Eclipſes*, whether of *Sun* or *Moon*, they have their excellent Uſes too. The Aſtronomer applies them to conſiderable Services in his Way; and the Geographer makes them no leſs uſeful in his; the Chronologer is enabled by them to amend his Accounts of Time, even of the moſt ancient Days, and ſo

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(*c*) *Ferunt Lunæ fœmineum ac molle Sidus, atque nocturnum, ſolvere humorem, & trahere, non auferre. Id manifeſtum eſſe quòd——Somno ſopitis torporem contractum in caput revocet.* Plin. L. 2. cap. 101.

down through all Ages; and the Mariner too can make them ſerviceable to his purpoſe, to diſcover his Longitude, to correct his Account at Sea, and thereby make himſelf more ſecure and ſafe in the untrodden Paths of the Deep.

So for the *Monthly Revolutions* of the Moon, beſides the Uſes they have in the daily Variations of the Tides, and perhaps cauſing ſome ſuch Revolutions too in the Humours and Bodies of Animals, and in the Works of Nature; beſides this, I ſay, they are manifeſtly of excellent Uſe in the Diviſions of Time, in Meaſuring out our Months, as the Sun doth our Days and Years, according to that Appointment of the Creator, Gen. i. 14. *And God ſaid, Let there be Lights in the Firmament of the Heaven, to divide the Day from the Night; and let them be for Signs, and*

and for Seaſons, and for Days, and Years.

And laſtly, as to the Lunar *Latitude*, or Progreſſes towards our Poles, beſides the Uſe hereof to the preventing the two frequent Eclipſes of the Sun and Moon, thoſe Vagations are of great Uſe to the polar parts of the World, in affording them a longer, as alſo a ſtronger and better Light, than if the Rays fell more oblique: Which muſt needs be a very great Comfort, and of wonderful Service to the Inhabitants of thoſe forlorn parts, in their long and tedious Nights, of ſome Days, yea ſome Months length: To Men, to enable them to diſpatch ſuch of their Affairs as are of perpetual and conſtant Neceſſity; and to other Animals of the Air, Land, or Waters, to enable them, with greater eaſe, and pleaſure, to get their Food, and paſs where their pleaſure leads them.

Thus the great CREATOR hath made the Moon to be of admirable Uſe to our Earth. And ſo wiſely hath he contrived his Works, that they are mutually ſerviceable to one another, ſo that what good Services one doth, the other as readily returneth again. Thus as the Moon is a Moon to us, ſo the Earth is, with great Reaſon concluded by the Philoſophers, to be a Moon to the Moon; not indeed a ſecondary Planet moving periodically about her, but ſuch a Planet, as reflects the Light of the Sun to her, and perhaps make ſuch like returns of Influx, as I ſaid the Earth receives from her. For it is not to be doubted, if the Earth reflects Light, and gravitates to the Moon, as well as the Moon to the Earth (which is highly probable) but that there is a mutual intercourſe, and return of their Influences, and good Offices. And this is ſtill more probable from the Likeneſs diſcernible between the Earth and the Moon, which is a ſtrong preſumption that the Moon may have the ſame Occaſions for the Earth, as the Earth for her. For that ſhe is an opake Body, and that her Surface is covered in ſome meaſure with Hills and Valleys, is manifeſt beyond all doubt to our Eye (*d*) as I before ſaid: And that ſhe hath an Atmoſphere is what hath been not long ſince (*e*) diſcovered: And that there are large Oceans and collections of Water is what I have before made probable (*f*). And therefore agreeing thus in Conſtitution and Make, their Occaſions for, and Influences upon each other are in all probability mutual, and much the ſame.

(*d*) See Book 5. Chap. 2. Note *c*.
(*e*) See before, Chap. 3. Note *a*.
(*f*) Book 5. Ch. 4. Note *a*, as alſo the Preface.

And after this Manner, the infinitely *wiſe Contriver* of the Univerſe ſeems to have tranſacted throughout that immenſe Space, by making all the ſeveral Globes uſeful to one another. Thus all the Planets of our Solar Syſteme are of conſiderable Uſe to us, all of them reflect Light unto us, and ſome of them a Light ſo bright and ſtrong (as particularly *Venus* and *Jupiter*) that they are a good Supply of the Moon's Abſence in the Night, as well as the Sun's. Nay the very *Secondaries* (which I ſhall ſhew are of greateſt Uſe to their primary Planets) have their Uſes too amongſt us; not only as being evident Demonſtrations of the great Works of God, but alſo in miniſtering to the Diſcovery of the Longitude of the moſt diſtant Places upon the Earth. So for the *Fixt Stars*, which I have before ſhewn to be (probably) ſo many Suns, miniſtering to as many Syſtemes of Planets; it is certain they are of great Uſe to us in ſupplying the Abſence of the Sun and Moon by Night. And there is no great Doubt to be made, but that the like Returns are made to them, and their Syſtemes by our Sun. So that here we have an admirable Oeconomy obſervable throughout all the viſible Regions of the Univerſe, in the mutual Aſſiſtances, and Returns, which one Globe affords the other, even at the greateſt Diſtance.

Chap. V.

Of the Moons, or Secondary Planets in general, which are obſerved about ſome of the Primary Planets.

HAVING taken a View of the Methods which are uſed for the accommodating the Earth with Light and Heat, let us caſt our Eye to the reſt of our *Solar Syſteme*, and examine whether any Thing of the like kind is to be found there. And here we ſhall find a no leſs admirable Scene of the great CREATOR's Care and Wiſdom, than we diſcovered in the Earth and Moon. In *Mars* indeed, we can diſcern a great Similitude with the Earth, in its Opacity and Spots, but we have not yet been able to perceive any Attendance of Moons, as in the other ſuperiour Planets; not ſo much probably becauſe there are none, but becauſe they are ſmall, or they reflect a weak Light, and are at a great Diſtance from us. And as for *Venus* and *Mercury*, there may be no Occaſion for any Attendants, by reaſon of their proximity to the Sun. But in the two higheſt, or more diſtant Planets, *Jupiter* and *Saturn*, we have a very noble, and entertaining Scene of the CREATOR's *Glory*. For whereas thoſe two Planets are at a much greater Diſtance, than any of the other Planets, from their Fountain of Light and Heat, the Sun; and as conſequently their Heat and Light are abated in proportion to the Square of their Diſtances; ſo to make them amends, they are ſurrounded with a more grand Retinue, of *Secondary Planets*, or Moons;

Jupiter with four, *Saturn* with five, as 'tis imagined; and probably more (*a*).

And an admirable Remedy this is, not only for the great Diſtance of theſe two Planets from the Sun, but alſo for the tardity of their periodick Motion in their reſpective Orbits. For whereas *Saturn* revolves round the Sun but once in near thirty

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(*a*) Mr. *Huygens* in his *Coſmotheor.* p. 99. gives this Account of the Diſcovery of the Satellites of *Jupiter* and *Saturn*, That it is *well known the Diſcovery of the Circumjovials is owing to* Galilæo; *that the brighteſt and outermoſt Circumſaturnial he happened to ſee with a* 12 *Foot Glaſs in the Year* 1655; *that the reſt are owing to* Caſſini, *who firſt ſaw them with a Glaſs of* Campani's *grinding, of* 36 *Feet, and afterwards with one of as many Feet above an hundred.* That *the Third and Fifth,* Caſſini *ſhewed him in* 1672, *and afterwards oftner.* That Caſſini *acquainted him, by Letter afterwards, with his Diſcovery of the Firſt and Second in* 1684. That *the two laſt are not eaſily diſcerned, and he cannot ſay he ever ſaw them.* That *beſides theſe Five, he ſuſpects there may be One or more lie concealed.* Of which ſee Chap. 7. following.

Years, and *Jupiter* but once in near twelve, it comes to paſs that the places near the two Poles of thoſe Planets, have a Night of near fifteen Years in *Saturn*, and ſix in *Jupiter*, ſuppoſing their Axes inclined to the Planes of their Orbits, as it is in our own Globe. But ſuppoſing (as it is imagined) that their Axes are not ſo much inclined, and that their Days and Nights, their Winters and Summers, are nearly equal; in this reſpect, the Caſe would be worſe, than in the long Nights, in the other Caſe: But in both Caſes, the polar Parts of both thoſe Planets, would be diſmal Regions of Darkneſs, when ſo long detained from the kindly Viſits of the Sun. But an admirable Remedy is found, and a glorious Scene of the great CREATOR's Works appears therein, as will be manifeſt by conſidering particulars in each of thoſe two ſuperiour Planets.

Chap. VI.

Of Jupiter'*s* Moons, Days, *and* Seaſons.

IN ſpeaking concerning the ſuperior Planets in particular, I ſhall begin with *Jupiter.* The Diſtance of this Planet from the Sun, is reckoned to be 343 millions of Miles farther from the Sun than we are; and by that Means, the Sun's Light and Heat are 27 times leſs there than with us, and its apparent Diameter, five times leſs (*b*). And conſidering

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(*b*) *Gregorii Aſtron.* L. 6. Prop. 5. Mr. *Huygens* makes the Light and Heat but 25 times leſs, and the apparent Diameter 5 times: *Coſmoth.* p. 103.

how vaſt a Globe *Jupiter* is, having its Superficies 100 Times, yea (according to Mr. *Huygens*'s Computations) 400 Times bigger than that of the Earth; in this Caſe, what vaſt Tracts of that Globe muſt needs lie in profound Darkneſs, and Deſolation, had no Remedy been provided! But there are divers provided. One is by the frequent Rotations of *Jupiter* round his own Axis; which being performed in leſs than 10 Hours, it comes to paſs, that what is wanting in the Strength, and Degree of Light and Heat, is compenſated by the frequent Returns thereof.

The other Remedy is by the Increaſe of the Number of *Moons* about *Jupiter*, who is attended (as I ſaid) with four, as we who are nearer the Sun, are with one. Concerning which theſe four Things are remarkable.

1. Their Bulk, which in all probability, is not in any of them leſs than our Earth, as the moſt ingenious Mr. *Huygens* concludes (*b*) from their Shade upon *Jupiter*'s Disk. By which partly it is that,

2. They reflect ſo ſtrong, brisk, and vivid a Light, as appears very illuſtrious, and entertaining, even to us at ſo great a Diſtance from it: Which cannot but be very pleaſing and comfortable to that Planet: Beſides the no leſs beneficial and friendly Influences conveyed therewith at the ſame Time.

3. Their due Diſtances from *Jupiter*, and from one another; and their agreeable periodick Revolutions, which I have formerly obſerved (*d*) to be in the moſt exact mathematical Proportions. By the firſt

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(*b*) Coſmotheor. p. 101.
(*d*) Book 4. Chap. 4.

of theſe, thoſe Satellites eſcape all diſagreeable Concourſes, and violent Oppoſitions, and, in the moſt kindly Manner, ſend their Influx to the Planet they wait upon: And by the latter, they are perpetually carrying about their Light, and other Benefits from place to place. For by the Motion of the Innermoſt, round once in leſs than two Days; of the next in about 3½ Days; of the Third in ſomewhat above a Week; and of the Outermoſt in near 17 Days: By theſe Means, I ſay, it happens very ſeldom that any part of *Jupiter* is at any Time without the Preſence and Attendance of one or more of thoſe Satellites; but one is viſiting one part, whilſt another is attending another, and another another part, and *Jupiter* himſelf making ſpeedy Returns and Revolutions all the while.

4. The laſt thing remarkable is the Latitudes of *Jupiter*'s Moons, or

their progreſſes towards his Poles, which are in a due proportion to their Diſtances and Periods: As I have before ſhewn, *Book* 4. *Ch.* 5.

And as the Latitudes of theſe Satellites differ, according to their Diſtances and Periods; ſo another remarkable Thing therein, is, that they ſhift their Latitudes, in longer or ſhorter Times, according as their Latitudes, or Vagations towards the polar Parts of *Jupiter*, are greater or leſſer. By which Means, ſome are making their progreſſes towards *Jupiter's* Poles one way, whilſt ſome are wandering the other way, and ſome are ſtaying there a longer Time, and ſome a leſſer and leſſer Time. By which quadruple Variety of Latitudes, and perpetual Changes of it, it comes to paſs, that thoſe large Tracts towards the polar Parts of that vaſt Planet, have their due Share in the light, and kindly ſervices, of its four Moons, and are ſeldom or never deprived of them.

Chap. VII.

Of Saturn's Moons, Ring, Days, *and* Seaſons.

HAVING ſeen the admirable proviſion made for the remedying *Jupiter*'s great Diſtance from the Sun; let us, in the laſt place, take a View of *Saturn*; which is above 200 millions of *Engliſh* Miles farther from the Sun than *Jupiter*, and near 700 millions of Miles farther than is our Earth. And here our Glaſſes, as imperfect as they are, have diſcovered ſo ſurprizing an Apparatus, that muſt needs ſtrike every one that views it with Wonder and Amazement.

For, in the firſt place, inſtead of four Satellites or Moons, as *Jupiter* hath, *Saturn* hath five, and probably more. Three of theſe I my ſelf have ſeen with Mr. *Huygens*'s 120 Foot Glaſs; but for want of a Pole of ſufficient Height to mount the Glaſs high enough, I am not ſure I have ſeen any more. And beſides thoſe five, which others have ſeen, there is great Reaſon to conclude there is a Sixth lying between the two Outermoſt, there being a larger Space between them, than is in proportion to what is found amongſt the reſt. And it is not improbable but that there are others alſo lying beyond the Fifth, or Outermoſt, but become inviſible at ſo great a Diſtance from us, by Means of ſome Obſcurity, ſuch as is obſervable in the Outermoſt it ſelf, which is never to be ſeen by us, but in the weſtern part of its Orbit, as Mr. *Huygens* well obſerves (*a*).

Theſe Satellites we may reaſonably conclude to be of a prodigious Bulk, for the reflecting of Light, and for their other Miniſtrations to *Saturn*, becauſe otherwiſe they could not be ſeen at ſo great a Diſtance as the Earth; and particularly one of them (*b*) is of that Magnitude, and its

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(*a*) The reaſon why *Saturn*'s fifth *Satellite* appears not on the Eaſtern, but Weſtern Part of its Orbit, Mr. *Huygens* very ſagaciouſly (like himſelf) conjectures to be, becauſe this *Satellite*, as the Moon doth to the Earth, always turns one and the ſame Side to *Saturn*, and becauſe this *Satellite* hath, he imagines, only one Part of its Surface clear, and the greateſt Part obſcure, and not able to reflect ſufficient Light to us, therefore all the Time that obſcure Part is turned towards us (which is whilſt the *Satellite* is in the Eaſtern Parts of its Orbit) it diſappears: But in the Weſtern Parts it appears, becauſe the bright Sides lie towards us. *Coſmotheor.* p. 118.

(*b*) It is the fourth *Satellite*, or Outermoſt but one (called from its firſt Diſcoverer, the *Hugenian Satellite*) that is ſo viſible.

its Light ſo brisk and vivid, that it appears very illuſtrious through our longer Glaſſes, and may be diſcerned with our ſhorter.

As to the *Diſtances*, the *Periods*, and *Latitudes* of thoſe Satellites, they being conſentaneous to what I have already taken Notice of in *Jupiter*, I ſhall not inſiſt upon them, but paſs to another proviſion made for the great Diſtance of that Planet; which is a Thing ſo ſingular to *Saturn*, ſo unuſual in all the reſt of the Creation, and ſo amazing, that it is an evident and noble Demonſtration of the great CREATOR's *Art* and *Care*; and that is *Saturn*'s *Ring*. Concerning which theſe Things are obſervable.

1. The prodigious *Size* of it, its great Breadth and vaſt Compaſs. This we may make a Judgment of, by comparing it with *Saturn* himſelf. And ſuppoſing the Diameter of *Saturn*

turn to be as is before determined, 93451 *Engliſh* Miles, the Diameter of his Ring will be 210265 ſuch Miles, and its Breadth about 29200 (*c*); an amazing Arch to an Eye placed in that Planet.

2. The due and convenient Diſtance of it from *Saturn* it ſelf; not cloſely adhering to it, becauſe that would annoy a large portion of *Saturn*'s Globe, by depriving it of the Sun's Rays, but environing it at about the Diſtance of its Breadth; by which Means the Sun's Light and Heat are permitted to enter between the Planet and its Ring, whilſt other Rays are, at the ſame Time, reflected upon the Planet by the Ring.

(*c*) Mr. *Huygens* in his *Syſtema Saturn.* p. 47. and *Coſmotheor.* p. 109. determines the Diameter of *Saturn*'s *Ring* to the Diameter of *Saturn*, to be as 9 to 4; and the Breadth of the Ring, and Diſtance of the Ring from *Saturn*'s Body, to be nearly equal, and accordingly theſe Numbers are defined here.

3. The Thickneſs of the Ring, which is hardly, if at all perceivable by us; which is as great a Benefit, as its edgling Shade would be an Annoyance, was the Ring thick.

4. Its Smoothneſs and Aptitude to reflect Light and Heat (*d*) is a wonderful Convenience in it. Was it full of Mountains and Valleys, and I may add Waters too, as in our Earth, and probably the Moon likewiſe, the Reflexions would be too weak to render the *Ring* viſible unto us, at ſo great a Diſtance as we are; but perceiving its Light to be ſo lively and ſtrong, as to render both it ſelf, and *Saturn* very illuſtrious, it is a Demonſtration of the Aptitude of its Structure, and Smoothneſs, for the Reflexion of Light and Heat to the Planet it ſerves.

(*d*) See *Huygen. Syſt. Saturn.* p. 70.

5. As the periodical Revolutions of the Earth, are an excellent and providential Contrivance, for thoſe uſeful and neceſſary Mutations we have of the Seaſons of the Year, ſo no doubt but the ſame Benefits accrue to thoſe Revolutions, which *Saturn* hath about the Sun. It is viſible, that as *Saturn* changes its place in its Orbit, ſo its *Ring* receives a variety of Aſpects (*e*) not only with reſpect to us, but to the Sun. Thus in one part of the Orbit it appears with a (*f*) larger Ellipſis, ſo as to exhibit a large

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(*e*) Every 14 or 15 Years *Saturn*'s *Ring* hath the ſame Face; appearing at one Time with large open *Anſæ*, at another Time with no *Ring* at all. Which Appearances is obtained by gentle Progreſſes from the one to the other Face. As, if the *Anſæ* are the largeſt, they gradually diminiſh, until no *Anſæ* or *Apertures* are to be ſeen in the *Ring*, and at laſt no *Ring* at all alſo. See *Fig.* 8.

(*f*) This Mr. *Huygens* ſhews is when *Saturn* is 20½ Degrees in *Gemini* and *Sagittary*. This was the a large Space between it and *Saturn*: In another Part, with a leſſer, and ſo with a leſſer Ellipſis, and ſometimes as only a ſlender ſtrait Line, and ſometimes it is not viſible at all (*g*): alſo ſometimes one ſide of the Ring is

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the Appearance it had in *April* 1708, and which it will again receive at the End of 1722; only with this Difference, that whereas the Ring traverſed the upper or northerly Part of *Saturn*'s Disk in 1708, it doth now, and will, for ſome Years to come, traverſe the lower or ſoutherly Part thereof, as is repreſented in *Fig.* 7.

(*g*) Mr. *Huygens* ſhews that for about 6 months before and after *Saturn*'s being in 20½ Degrees of *Virgo* and *Piſces*, the Ring is not viſible, but *Saturn* appears round. *Syſt. Saturn.* p. 59, 74, &c. And accordingly at this very Time, there is no Appearance of the Ring, only a ſmall narrow Liſt or Belt croſſeth the Middle of *Saturn*'s Disk, of a colour ſomewhat different from the reſt of *Saturn*'s Face, and in the Place where the Ring ſhould be. This Appearance of *Saturn* is repreſented in Fig. 8. which is the Appearance he had through a very good 34 Foot Glaſs, at the latter End of *Octob.* and beginning of *Nov.* this preſent Year 1714. But a little before this, *viz.* on *Sept.* 26. I could through an 126 Foot Glaſs diſcern the narrow Ends of the Ring on each Side *Saturn*. A Repreſentation of which I have given in Fig. 9.

enlightened, and reflects Light towards one part of *Saturn*, ſometimes the other enlightens another part; and there is no doubt, but that as our Earth has its Seaſons, according to its poſition to the Sun, in its periodical Motion in its Orbit; ſo *Saturn* throughout his Period, hath his Seaſons according unto his poſition to the Sun, and the various Reflexions of the Ring upon the ſeveral parts of his Globe (*h*).

Theſe five Things obſervable in *Saturn*'s *Ring*, we have pretty good aſſurance of, from our views through good Glaſſes. But there is a

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(*h*) There is very great Reaſon to imagine this doth certainly happen in *Saturn*, becauſe as Mr. *Huygens* obſerves, *Saturn* appears ſometimes more ſplendid than at other times. *Ita ſemper* (ſaith he) *quò propiùs verſus Cancri & Capricorni ſigna acceſſerit, eò majorem, aut certè ſplendidiorem, etiam abſque Teleſcopio appariturum, quippe Annuli Ellipſi ſemper ſe latiùs pandente.* Huygen. Syſt. Saturn. p. 56.

6. Thing I ſhall add as only conjectural, and that is, A Suppoſition that the Axis of *Saturn* (*i*) is inclined (and that pretty much alſo) to the Plane of its Ring, or the Plane of its Orbit at leaſt; and that he hath a Diurnal Rotation in ſome certain ſhort Space of Time. For without theſe two Conveniences, very large Tracts of *Saturn* would ſuffer extremely for want of the Sun. For if *Saturn* hath no other Motion, but that round the Sun in its Orb, one part muſt be excluded from the Sun's Viſits for 15 Years, whilſt the other partakes all the while of them; and one Hemiſphere will enjoy the Benefit of the Ring, whilſt the other is eclipſed by it: And in this Caſe the

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(*i*) Mr. *Huygens* determines the Inclination of *Saturn's* Axis to the Plane of his Orbit to be 31 *gr.* as that of the Earth is 23 *Degrees. Coſmotheor.* p. 108.

Ring would be nearly as prejudicial to the eclipſed part, as it is uſeful to the enlightened. But ſuppoſing *Saturn* to move round in the ſame, or a ſhorter Time than *Jupiter*, and in a Path pretty much inclined to the Ring, all parts then of that vaſt Planet will have their frequent Returns of Day and Night, of Heat and Cold. And ſince this is what is diſcernible in the other Planets, and is no leſs neceſſary for the Benefit and Comfort of this, we may reaſonably conclude the Thing to be probable, although not diſcernible at *Saturn*'s great Diſtance from us.

CHAP. VIII.

The Concluſion.

THUS I have taken a View of the proviſion made for thoſe two grand, and univerſal Neceſſaries, Light and Heat; Things, in all probability, no leſs neceſſary for the other Globes, than for our own; and Things which not only Animals cannot ſubſiſt without, but what all Things here below, ſtand in need of, as well as they. When therefore we actually ſee, and feel thoſe indulgent proviſions, thoſe amazing Acts of the great CREATOR; when we have Views of their extent into Myriads of other the moſt diſtant Globes; when (to go no farther) we ſee in our own Syſteme of the Sun, ſuch a prodigious Maſs of Fire as the Sun is, placed in the Center, to ſcatter away the Darkneſs, and to warm and cheriſh us by Day; and ſuch a noble Retinue of Moons and Stars, attending and aſſiſting us by Night; when we ſee this *Indulgence*, this *Care* of the CREATOR, extended to all the other Planets, and that, according to their ſeveral Diſtances, they have a proportionate proviſion of the greater Number of Moons, and *Saturn* a ſtupendious *Ring* beſides, to ſupply the Decreaſe of Light and Heat; who can be otherwiſe than amazed at ſuch providential, ſuch uſeful, ſuch well contrived, ſuch ſtately *Works* of GOD! Who can view their Glories, and partake of their beneficial Influences, and at the ſame Time not adore the *Wiſdom*, and praiſe the *Kindneſs* of their CONTRIVER and MAKER! But above all, ſhould there be any found, among rational Beings, ſo ſtupid, ſo vile, ſo infatuated with their Vices, as to deny theſe *Works* to be GOD's, and aſcribe them to a *Neceſſity of Nature*, or indeed a mere *Nothing*, namely *Chance!* But ſuch there are to be met with among our ſelves, and ſome ſuch the Prophet tells us of, *Iſai.* 5. 11, 12. Men that had ſo debauched themſelves with drink, and enervated their Minds by pleaſures, that *they regarded not the Work of the Lord, neither conſidered the Operation of his Hands.* Such perſons having led their Lives in ſuch a Manner, as to wiſh there was no GOD, to call them to account, would then perſuade themſelves there is none; and therefore ſtupidly aſcribe thoſe manifeſt demonſtrations of the infinite *Power* and *Wiſdom* of GOD, to a mere Nothing, rather than to their great Author. But may we not with as good Reaſon, imagine a lighted Candle, a well made Culinary Fire, a flaming Beacon, or Light-houſe, to be the Work of *Chance*, and not of *Man*, as thoſe Glories of the Heavens not to be the *Works of GOD?* For it is very certain, that as much Wiſdom, Art, and Power worthy of God, is ſhewn in the Lights of the Heavens; as there is in thoſe upon Earth, worthy of Man, which none can doubt were contrived and made by Man. And if from theſe mean Contrivances and Works of Man, we conclude them to be the Works of Man; why not the grand, the amazing Works of the Heavens, ſurpaſſing all the Wit and Power of Man, why not theſe I ſay, the Works of ſome Being as much ſuperior to Man? According to the Argument of *Chryſippus* which ſhall conclude this Book. *If there be any Being that can effect thoſe Things, which Man, although endowed with Reaſon, is not able to effect; that Being*

ing is certainly greater, and ſtronger, and wiſer than Man. *But* Man *is not able to make the Heavens; therefore the Being that did make them, excels* Man *in Art, Counſel, Prudence and Power.*

BOOK VIII.

Practical Inferences

From the foregoing

SURVEY.

IN the foregoing ſeven Books having taken a View of what preſents it ſelf to us in the *Heavens*, and ſeen a Scene of the greateſt Grandeur, a Work well contrived, admirably adapted, and every Way full of Magnificence; all that now remains is, to endeavour to make theſe Views and Conſiderations uſeful to our ſelves. Which I ſhall do in the following Chapters.

CHAP. I.

The Exiſtence of GOD collected by the Heathens from the Works of the Heavens.

THE firſt and moſt ready and natural Deduction we can make from ſuch a glorious Scene of Workmanſhip, as is before repreſented, is to conſider, *Who the Great Workman was?*

That the Author of all this glorious Scene of Things was GOD, is ſuch a Concluſion, that even the moſt ignorant, and barbarous part of Mankind have been able to make from the manifeſt Signals viſible therein; Signals ſo plain and concluſive, that *Tully's Stoick* (*a*) cites it as *Ariſtotle's* Opinion, *That if there were ſuch a Sort of People, that had always lived under the Earth, in good and ſplendid Habitations, adorned with Imagery and Pictures, and furniſhed with all Things that thoſe accounted happy abound with: And ſuppoſing that theſe People had never at any Time gone out upon the Earth, but only by Report had heard there was ſuch a Thing as a Deity, and a Power of the Gods; and that at a certain Time afterwards, the Earth ſhould open, and this People get out of their hidden Manſions into the Places we inhabit: When on the ſudden they ſhould ſee the Earth, the Seas, and the Heavens; perceive the Magnitude of the Clouds, and the Force of the Winds; behold the Sun,*

(*a*) De Nat. Deor. L. 2. c. 37.

and its Grandeur and Beauty; *and know its Power in making the Day, by diffuſing his Light throughout the whole Heavens*; *and when the Night had overſpread the Earth with Darkneſs, they ſhould diſcern the whole Heavens beſpread and adorned with Stars, and ſee the Variety of the Moon's Phaſes in her Increaſe, and Decreaſe, together with the Riſings and Settings, and the ſtated and immutable Courſes of all theſe throughout all Eternity*; *this People, when they ſhould ſee all theſe Things, would infallibly imagine that there are Gods, and that thoſe grand Works were the Works of the Gods.* Thus have we the Opinion and Concluſion of two eminent Heathens together, *Ariſtotle*, and *Tully*'s *Stoick*.

And if the *Heavens* ſo plainly *declare the Glory of God, and the Firmament ſheweth his Handywork*;

work (b); if thoſe Characters, thoſe Impreſſes of the divine Hand, are ſo legible, that *their Line is gone out through all the Earth; and their Words to the End of the World, ſo that there is no Language, Tongue, or Speech where their Voice is not heard*; nay if theſe Things are ſuch, that even a ſubterraneous People would, at firſt ſight, conclude them to be GOD's *Work*; how daring and impudent, how unworthy of a rational Being is it, to deny theſe Works to GOD, and aſcribe them to any Thing, yea a mere *Nothing*, as *Chance* is, rather than GOD? *Tully*'s *Stoick* laſt mentioned denieth him to be a Man who ſhould do this. His Words (c) are, *Who would ſay he is a Man, who when he ſhould behold the Motions of the Heavens to be ſo certain, and the Orders of the Stars ſo eſtabliſhed, and*

(b) *Pſal.* xix. 1, &c.
(c) *Cicero* ibid. cap. 38.

all Things ſo well connected and adapted together, and deny that Reaſon was here, and ſay theſe Things were made by Chance, which are managed with ſuch profound Counſel, that with all our Wit we are not able to fathom them? What! ſaith he, *when we ſee a Thing moved by ſome certain Device, as a Sphere, the Hours, and many Things beſides; we make no doubt but that theſe are the Works of Reaſon. And ſo when we ſee the noble Train of the Heavens, moved, and wheeled about, with an admirable Pace, and in the moſt conſtant manner, making thoſe anniverſary Changes, ſo neceſſary to the Good and Preſervation of all Things; do we doubt whether theſe Things are done by Reaſon, yea, by ſome more excellent and divine Reaſon? For,* ſaith he, *ſetting aſide the Subtilties of Diſputation, we may actually behold with our Eyes in ſome Meaſure, the Beauty of thoſe Things*

Things which we aſſert are ordered by the Divine Providence. And then he enters into a long detail of Particulars of this kind, too many to be named here.

Thus *Cicero,* throughout whoſe Works ſo many paſſages of this Nature occur, that it would be endleſs to cite them: And therefore one obſervation that ſhews what his Opinion was of the Senſe of Mankind in the Matter, ſhall cloſe what he ſaith, and that is in his Book *de Legibus* (*d*), where he ſaith, *Among all the tribes of Animals, none but Man hath any Senſe of a God; and among mankind there is no Nation ſo ſavage and barbarous, which although ignorant of what God it ought to have, yet well knows it ought to have one.*

And after the ſame manner *Seneca* (*e*), who inſtanceth in two Things

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(*d*) L. 1. c. 8.
(*e*) Epiſt. 117.

to ſhew the Deference we are apt to give to the general preſumption and conſent of Mankind. One is in the *Immortality of the Soul:* The other is in the *Exiſtence of a Deity* ; *which,* ſaith he, *among other Arguments we collect from the innate Opinion which all Men have of the Gods : For there is no Nation in the World ſo void of Law and Morality, as not to believe but there are ſome Gods.* Nay ſo poſitive he is in this Matter, that in another place he expreſsly ſaith, *They lye that ſay, they believe there is no God. For although by Day they may affirm ſo to* thee, *yet by Night they are to* themſelves *conſcious of the contrary.* Much more could I cite out of this famous Heathen, but one paſſage, relating to the Heavens, ſhall ſuffice, and that is in his Diſcourſe ſhewing *Why Evils befal good Men, ſeeing there is a Divine Providence* (*e*).

(*e*) *Quare bonis viris, &c.* c. 1.

He takes it for granted in this Diſcourſe, that there is ſuch a Thing as a DIVINE POWER and PROVIDENCE *governing the World*; and he ſaith, *it was needleſs for him to ſhew that ſo great a Work* [as the World] *could not ſtand without ſome Ruler; that ſo regular Motions of the Stars, could not be the Effects of a fortuitous Force, and that the Impulſes of Chance, muſt be oftentimes diſturbed and juſtle: That this undiſturbed Velocity, which bears the weight of ſo many Things, in the Earth and Seas, ſo great a Number of heavenly Lights, both very illuſtrious, and alſo ſhining by a manifeſt diſpoſal, muſt needs proceed by the Direction of ſome eternal Law: That this can never be the Order of ſtraggling Matter; neither is it poſſible for things fortuitouſly and raſhly combined, to depend upon, and manifeſt ſo much Art.* Divers of which Matters he proceeds to inſtance in.

Thus *Cicero* and *Seneca*: To whoſe Evidences I might have added many others, particularly a great deal out of *Plato* (the *divine Plato*, the *Homer of Philoſophers*, as he is called by the Ancients:) But it would be needleſs as well as tedious, ſince theſe two former have given us the Senſe of Mankind, as well as their own Opinion in the Matter.

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CHAP. II.

GOD's Perfections demonſtrated by his Works.

AS GOD's *Works* have been ſhewn to be manifeſt Demonſtrations of his *Exiſtence*; ſo they are no leſs of his *Perfections*, particularly of his infinite *Power*, *Wiſdom* and *Goodneſs*; inaſmuch as every Workman is known by his Work. A Palace that ſhould have nothing defective in Situation, Beauty, or Convenience would argue the Architect to have been a Man of Sagacity, and skilful in Geometry, Arithmetick, Opticks, and all other Mathematical Sciences, ſerving to make a Man a complete Architect; yea to have ſome Judgment in Phyſick, and Natural Philoſophy too. And ſo this glorious Scene of GOD's Works, the Heavens, plainly demonſtrate the Workman's infinite *Wiſdom* to contrive, his *Omnipotency* to make, and his infinite *Goodneſs*, in being ſo indulgent to all the Creatures, as to contrive and order all his Works for their Good. For what leſs than *Infinite*, could effect all thoſe grand Things, which I have, in this Diſcourſe, ſhewn to be manifeſt in the Heavens? What Architect could build ſuch vaſt Maſſes, and ſuch an innumerable Company of them too, as I have ſhewn the Heavens do contain? What *Mathematician* could ſo exactly adjuſt their Diſtances? What *Mechanick* ſo nicely adapt their Motions, ſo well contrive their Figures as in the very beſt Manner may ſerve to their own Conſervation and Benefit, and the Convenience of the other Globes alſo? What *Naturaliſt*, what *Philoſopher* could impregnate every Globe, with a Thing of that abſolute Neceſſity to its Conſervation, as that of Gravity is? What *Optician*, what *Chymiſt* could ever have hit upon ſuch a noble Apparatus for Light and Heat, as the Sun, the Moon, and the Stars are? could amaſs together ſuch a Pile of Fire as the Sun is? could appoint ſuch Lights as the Moon and other Secondaries are? None certainly could do theſe things but GOD.

CHAP. III.

Of GOD's Relation to us, and the Duties reſulting from thence.

IT appearing, from the laſt Chapter, how great a *Being* the CREATOR is, it is Time to conſider what Relation he ſtands in to us, and what is due from us to him. His Relation to us is that of CREATOR; and as ſuch, of *Conſervator*, *Sovereign LORD*, and *Ruler*, one that hath an abſolute Power over us, and all Things belonging to us, that can ſubject us to what Laws he ſees fit, and that can reward or puniſh us, as we deſerve. And in this Caſe, the leaſt we can do, is to *revere* and *fear* him at all Times, to *worſhip* and *ſerve*

ſerve him with all our power, to *comply* with his holy Will ſincerely and heartily, and to *obey* him in all things he hath either forbidden, or enjoined. And conſidering alſo how great *Indulgence* and *Love* the CREATOR hath ſhewed in his Works throughout the Univerſe, it naturally follows that we ought to be truly *thankful* to him for his Mercy and Kindneſs, and to *love* him for his Love and Goodneſs.

Theſe Kind of Concluſions are ſo natural, that the very Heathens have in ſome Meaſure made them. Thus *Cicero*'s *Stoick* before cited, (*a*) *Quid verò? hominum Ratio non,* &c. *What? doth not Man's Reaſon penetrate as far as even the very Heavens? For we alone of all Animals have known the Riſings, Settings and Courſes of the Stars: By Mankind it is*

(*a*) De Nat. Deor. L. 2. c. 61.

that the Day, the Month, and Year, is determined; that the Eclipſes of the Sun, and Moon are known, and foretold to all Futurity, of which Luminary they are, how great they will be, and when they are to happen. Which thing the Mind contemplating, it receives from hence (*b*) *the Knowledge of the Gods: From whence ariſes Piety; to which is joined Juſtice, and the other Virtues, from which ſprings that bleſſed Life which is equal unto, and like that of the Gods themſelves, and in no reſpect yielding to thoſe Cæleſtials, except in Immortality, which is not neceſſary to happy Living.* And in his Book *De Legibus* (*c*) *Cicero* brings in his Collocutor ſaying, *Sit igitur hoc à principio perſuaſum*, &c. i. e. *Let this be what every*

(*b*) Some read it inſtead of *Accipit ad Cognitionem Deorum; Accipit ab his Cognitionem Deorum.*

(*c*) Lib. 2. c. 7.

Member of the Commonwealth is fully convinced of from the beginning, That the Gods are Lords and Governours of all things; that whatſoever things are done, they are managed by their Influence, Rule and Divinity; that they merit a great deal of Mankind; and obſerve what every one is, what he doth, what he admits into his Mind, with what Mind, what Piety he cultivates Religion; and that they take an Account both of the Righteous and Wicked. For, ſaith he, *Minds that are indued with theſe Principles, will ſcarce ever depart from that Opinion that is uſeful and true.* And a little after (*d*) one of the Laws ariſing from hence he ſaith is, *Let Men approach the Gods with Purity, let them practiſe Piety: For he that doth otherwiſe, God himſelf will be the avenger of.* This purity and ſincerity is

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(*d*) *Cap.* 8.

ſo neceſſary a Concomitant of Religion, and divine Worſhip, according to *Cicero*, that he makes it, in another place, to be that which diſtinguiſhes Religion from Superſtition (*e*) *Cultus autem Deorum eſt optimus*, &c. *But that Religion, that Worſhip of the Gods is the beſt, the pureſt, the holieſt, and fulleſt of Piety, that we always revere and worſhip them with a pure, upright, and undefiled Mind and Voice. For*, ſaith he, *not only the Philoſophers, but our Forefathers, have diſtinguiſted Superſtition from Religion*; which he aſſigns the Difference of, and then tells us, *That the one hath the Name of a Vice, the other of Praiſe.*

Thus as the Heathens, have by the Light of Nature, deduced the Exiſtence and Attributes of God from his Works, and particularly thoſe of the Heavens; ſo have they,

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(*e*) De Nat. Deor. L. 2. c. 28.

at the ſame Time, collected what the principal Duties are which Men owe to God; ſo reaſonable, ſo natural, ſo manifeſt they are to all Mankind.

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CHAP. IV.

Lactantius *his Argument againſt the Heathen Gods.*

THE next Inference ſhall be one made by the eloquent *Lactantius* (*a*) *Argumentum illud quo colligunt univerſa Cœleſtia Deos eſſe*, &c. i. e. *That Argument whereby they conclude the heavenly Bodies to be Gods, proveth the contrary: For if therefore they think them to be Gods, becauſe they have ſuch certain and* well contrived *rational Courſes, they err. For from hence it appears*

(*a*) Inſtitut. L. 2. c. 5.

pears that they are not Gods, becauſe they are not able to wander out of thoſe Paths that are preſcribed them: Whereas if they were Gods, they would go here, and there, and every where without any Compulſion, like as Animals upon the Earth do, whoſe Wills being free, they wander hither and thither, as they liſt, and go whitherſoever their Minds carry them.

Thus *Lactantius*, with great Reaſon, refutes the Divinity of the *heavenly Bodies*; which on the contrary are ſo far from being Gods, and Objects of divine Honour and Worſhip, that ſome of them have been taken to be Places of Torment. Thus *Comets* particularly, which muſt needs have a very unequal and uncomfortable Temper of Heat and Cold, by Reaſon of their prodigiouſly near Approaches to the Sun, and as great Receſſes from it. Thus according to the before commended Sir *Iſaac Newton's* *ton*'s (*b*) Computation, the Comet in 1680, in its Perihelion, was above 166 times nearer the Sun than the Earth is; and conſequently its Heat was then 28000 times greater than that of Summer: So that a Ball of Iron as big as the Earth, heated by it, would hardly become cool in 50000 Years. Such a Place therefore, if deſigned for Habitation, may be imagined to be deſtined rather for a Place of Torment, than any other Sort of living.

But above all, the Sun it ſelf, the great Object of Heathen Worſhip, is by ſome of our own learned Countrymen ſuppoſed to be probably the Place of *Hell*. Of which Mr *Swinden* hath written a Treatiſe called, *An Enquiry into the Nature and Place of Hell.*

(*b*) Principia, *p.* 466.

CHAP.

CHAP. V.

This Survey of the Heavens teaches us not to overvalue the World; with Reflections of the Heathen Writers thereupon.

FROM the Conſideration of the prodigious Magnitude and Multitude of the Heavenly Bodies, and the far more noble Furniture and Retinue which ſome of them have more than we, we may learn not to overvalue this World, nor to ſet our Hearts too much upon it, or upon any of its Riches, Honours, or Pleaſures. For what is all our Globe but a Point, a Trifle to the Univerſe! a Ball not ſo much as viſible among the greateſt Part of the Heavens, namely the Fixt Stars. And if Magnitude, or Retinue may dignify a Planet, *Saturn* and *Jupiter* may claim the preference: Or if Proximity to the moſt magnificent Globe of all the Syſteme, to the Fountain of Light and Heat, to the Center, can honour and aggrandize a Planet, then *Mercury* and *Venus* can claim that Dignity. If therefore our World be one of the inferiour Parts of our Syſteme, why ſhould we inordinately ſeek and deſire it? But above all, why ſhould we unjuſtly graſp at it, and be guilty of Theft or Rapine, Lying or Cheating, or any Injuſtice, or Sin for it? Why ſhould we ſacrifice our Innocence for it, or part even only with a good Name for it, which *Solomon* ſaith (*a*) *is rather to be choſen than great Riches*? Why ſhould we do this, if we were ſure of

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(*a*) *Prov.* xxii. 1.

gaining the whole terraqueous Globe, much leſs do it for a ſmall Pittance of it, as the beſt Empire in the World is? For as our bleſſed Saviour argues, Matt. xvi. 26. *What is a Man profited, if he ſhould gain the whole World, and loſe his own Soul? or what ſhall a Man give in exchange for his Soul?*

But paſſing over the Arguments which Chriſtianity ſuggeſts, let us ſee how ſome of the Heathen Writers deſcant upon this Subject. *Pliny* (*b*) is very pathetical in his Reflexions, when he had ſhewn what little Portions of the Earth were left for us, and what large Tracts were render'd (as he thought) uſeleſs, the frigid Zones being frozen up with exceſſive Cold, the torrid Zone being burnt up (as the Opinion then was) with as exceſſive Heat, and

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(*b*) Nat. Hiſt. L. 2. c. 68.

other parts drowned by the Sea, Lakes and Rivers, and others covered with large Woods, Deſarts, or barren Mountains: he then exclaims thus, *Hæ tot portiones terræ*, &c. i. e. *Theſe little parcels of Land*, which are left for our Habitation, *yea, as many have taught this Point of the World (for no other is the Earth in reſpect of the Univerſe) this is the Matter, this the Seat of our Glory: here it is we bear our Honours; here we exerciſe our Authority; here we covet Riches; here Mankind makes a Buſtle; here we begin our civil Wars, and ſoften the Earth with mutual Slaughters.* And then having ſhewn how by Fraud and Violence Men ſtrive to enlarge their Eſtates, ſaith he, *What a little part of thoſe Lands doth he enjoy? and when he hath augmented them, even to the meaſure of his Avarice, what a poor pittance is it that his dead body at laſt poſſeſſeth?* Thus *Pliny*. And after the ſame manner *Seneca* reflects upon the matter (*c*), when he ſhews how Virtue tends to make a Man completely happy; among other things, by preparing him for the Society of God, by enabling the Mind to ſoar above the things here below, and to make him laugh at the coſtly Pavements of the Rich, yea the whole Earth with all its Wealth. *Nec enim poteſt*, ſaith he, *ante contemnere porticus*, &c. i. e. *A Man can never be able to ſlight the ſtately Piazzas, the noble Roofs ſhining with Ivory, the curiouſly clipped Woods, and the pleaſant Rivulets conveyed to the Houſes, until he hath ſurveyed the whole World, and ſpying from above our little Globe of Earth, covered in a great meaſure by the Sea, and where it is not, is far and near ſqualid, and either parched with Heat* or *frozen with Cold, he*

(*c*) *Nat. Quæſt.* L. 1. Præf.

ſaith to himſelf, Is this that Point which by Fire and Sword is divided among ſo many Nations? O how ridiculous are the Bounds of Mortals! The Iſter *bounds the* Dacians, *the* Strymon *the* Thracians, Euphrates *the* Parthians, *the* Danube *parteth the* Sarmatians *and* Romans, *the* Rhine *gives bounds to* Germany, *the* Pyrenees *to* France *and* Spain, *and between* Ægypt *and* Æthiopia *lie the vaſt uncultivated ſandy Deſarts. If any could give human Underſtanding to Ants, would not they too divide their Molehill into divers Provinces? And when thou lifteſt up thy ſelf in thy truly great Province, and ſhalt ſee* the armed hoſts paſſing here, and lying there, as if ſome great matter was to be acted, conſider that this is no more than the running of Ants in a molehill. *For what difference between them and us, but only the meaſure of a little Body? That is but a Point in which thou ſail-*

eſt, in which thou wageſt War, in which thou diſpoſeſt of Kingdoms. But above there are vaſt ſpaces, to whoſe poſſeſſion the mind is admitted, provided it brings but little of the Body along with it, that it is purged of every vile thing, and that it is nimble and free, and content with ſmall matters. And ſo he goes on to ſhew that when the Mind is once arrived to thoſe celeſtial Regions, how it is come to its proper Habitation; is delivered from its Bonds; hath this argument of its Divinity, that divine things delight and pleaſe it, and is converſant with them as its own; that it can ſecurely behold the Riſings and Settings and various courſes of the Stars; that it curiouſly pries into all thoſe matters, as nearly appertaining to it ſelf: that then it contemns the narrow bounds of its former Habitation, it being but a trifling Space, of a few days Journey, from the utmoſt Limits of *Spain* to the very *Indies*; whereas the celeſtial Regions afford a path for the wandering of the ſwifteſt Star for 30 years, without any reſiſtance; in which Regions he tells us the Mind arrives to the knowledge of thoſe things at laſt, which it had before long enquired after, and there begins to know GOD. Thus *Seneca*; which ſhall ſuffice for this third Inference.

CHAP. VI.

That we ſhould aſpire after the Heavenly State.

I Shall deduce only one thing more from my preceding View of the Heavens, and that is to aſpire after the Heavenly State, *to ſeek the things that are above.* We are naturally pleaſed with new things, we take great Pains, undergo dangerous

Voyages, to view other Countries: with great Delight we hear of new Diſcoveries in the Heavens, and view thoſe glorious Bodies with great Pleaſure through our Glaſſes. With what Pleaſure then ſhall departed happy Souls ſurvey the moſt diſtant Regions of the Univerſe, and view all thoſe glorious Globes thereof, and their noble Appendages with a nearer View? Only let us take eſpecial care to *ſet our Affections on things above*; to be *ſpiritually, not carnally minded*; and ſo to *run the Race which Chriſt hath ſet before us*, that we may arrive to that *Place which he hath prepared* for his faithful Servants, that he may *receive us unto himſelf, that where he is, we may be alſo*; *in whoſe preſence is fulneſs of joy, and at whoſe right hand are pleaſures for evermore.*

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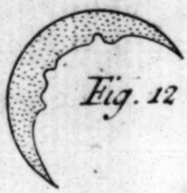

Fig. 12

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Page 119

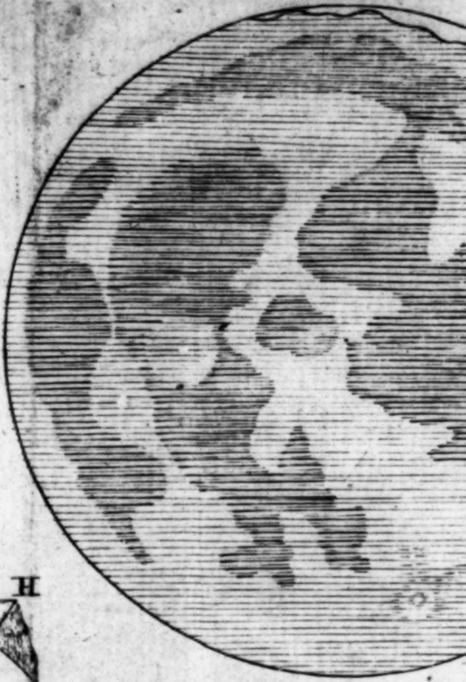
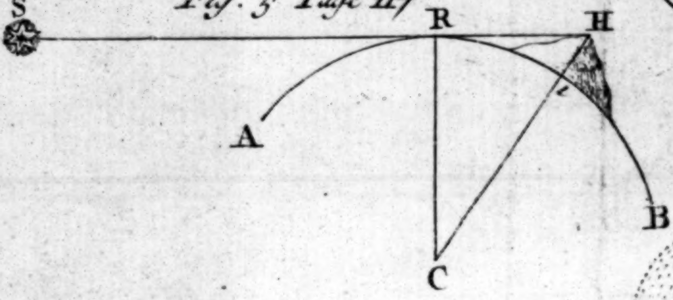
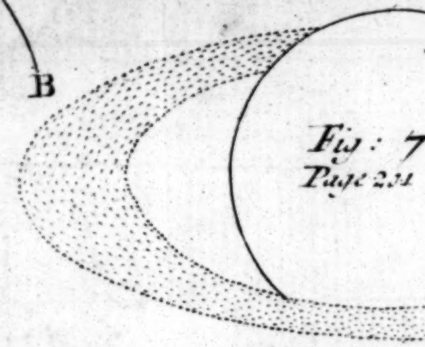


Fig. 5 Page 117





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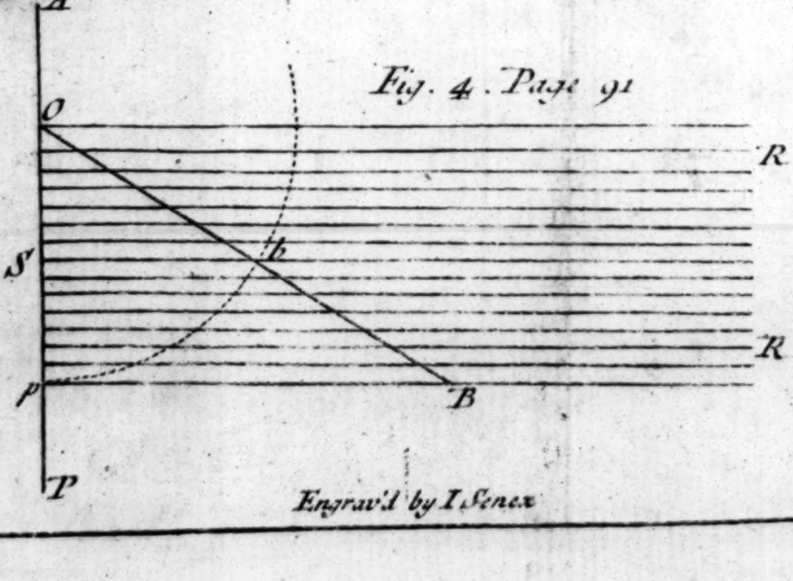
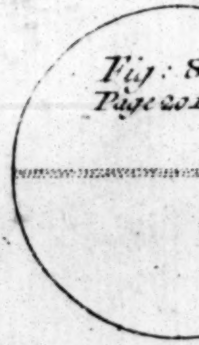
Page 201

Fig. 4. Page 91





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Page 201

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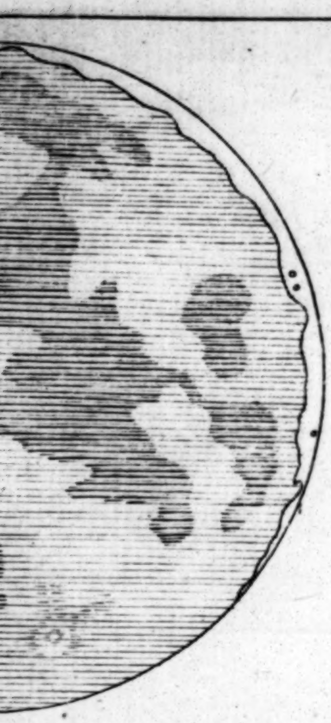


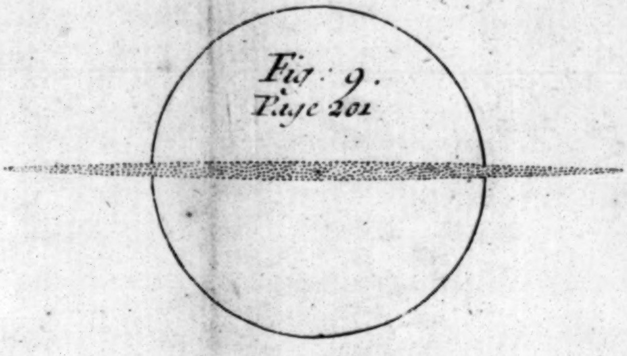
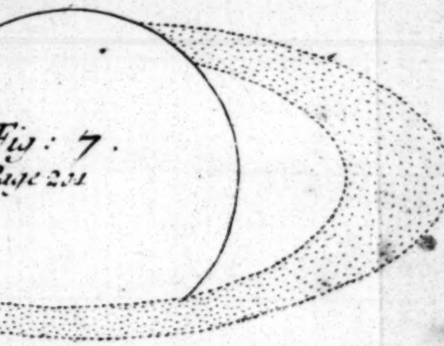


Fig: 9.
Page 201



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Page 201

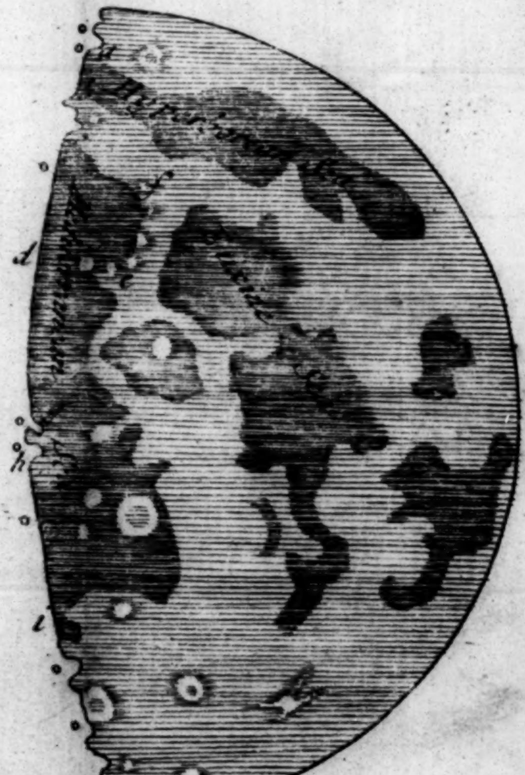
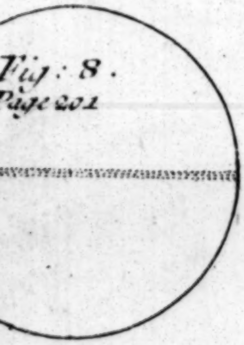


Fig: 11.
Page 84



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Page 201

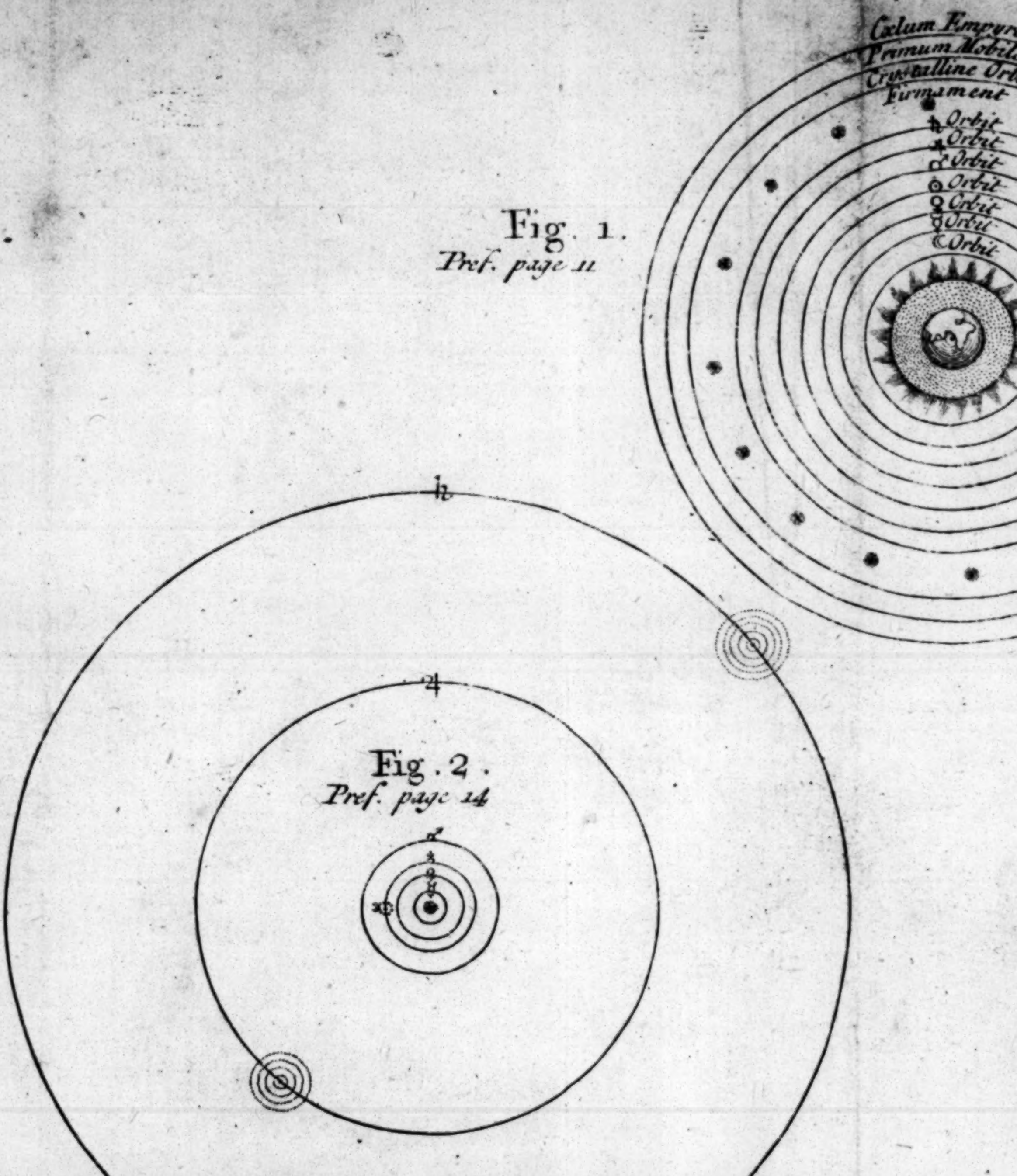

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Fig. 2.
Pref. page 14

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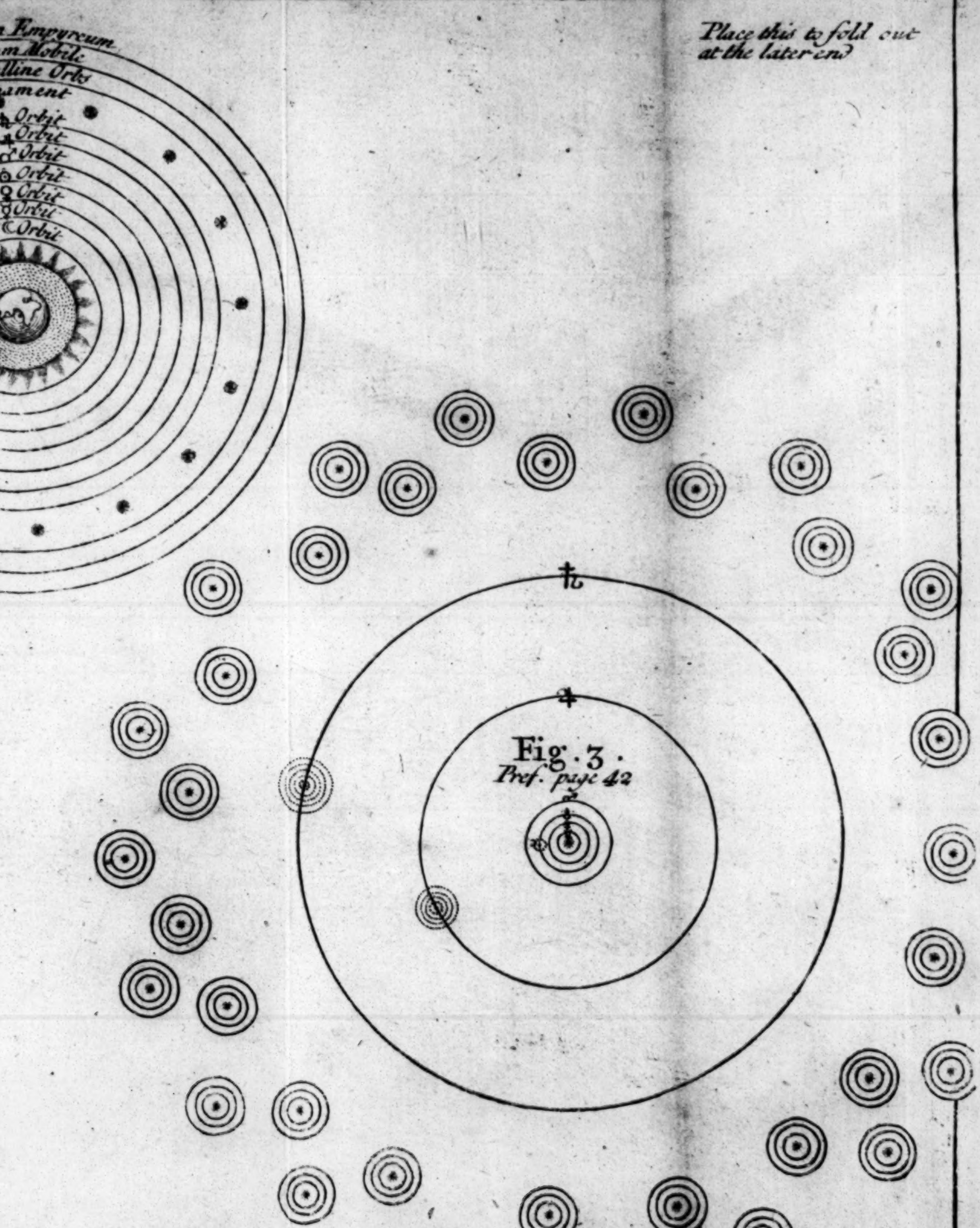
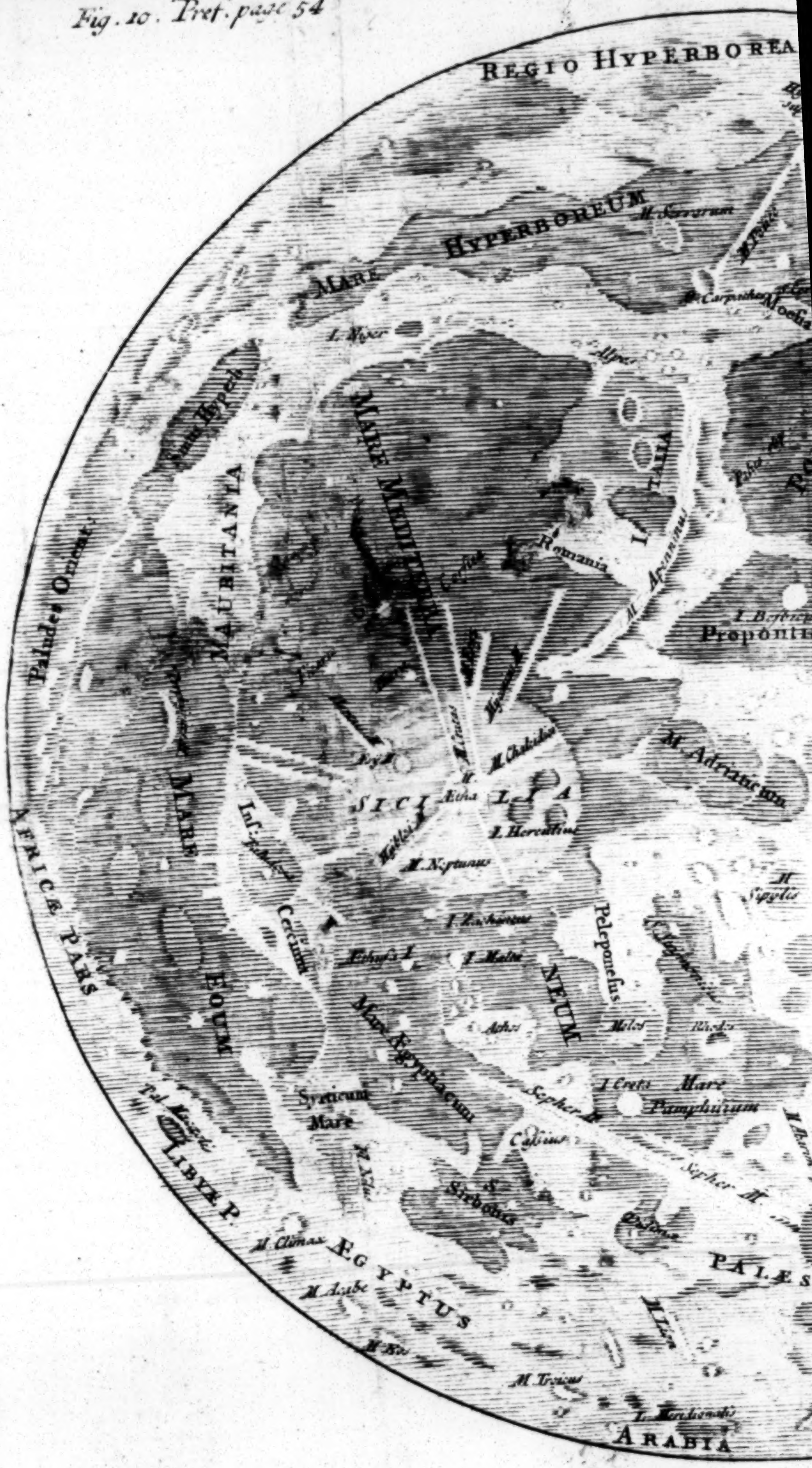


Fig. 3.
Pref. page 42

Fig. 10. Pref. page 54



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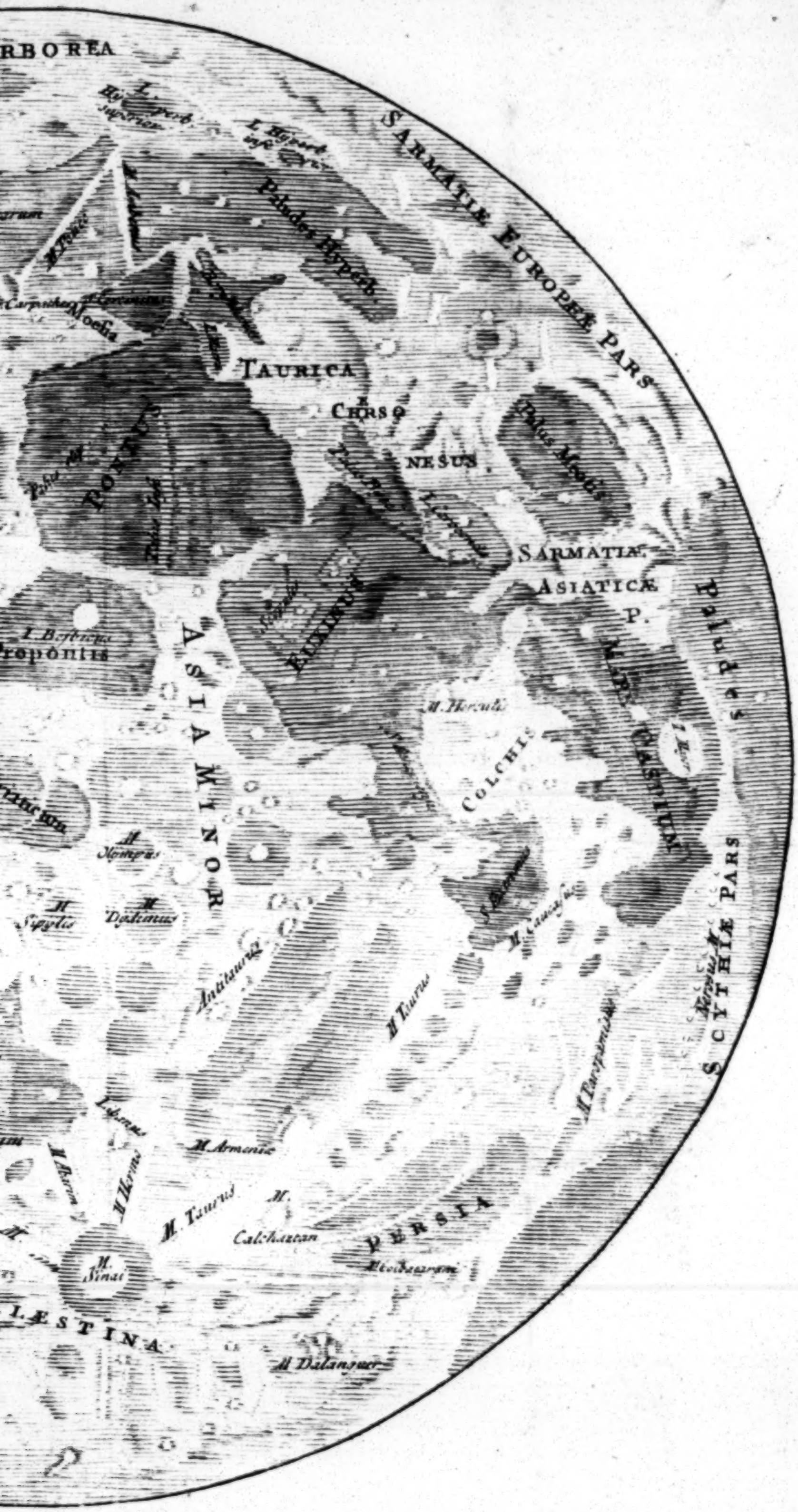

An Alphabetical

INDEX

To the preceding Book.

A.

ÆLIAN's Opinion of the Exiſtence of a God Page 3
Alps, their Height 118
Andes 119
Ariſtotle's Arguments for God 67, 220
Atheiſts held monſtrous by the Heathens 3
Atheiſm unreaſonable 215
Atmoſphere's great Uſe 180
Attraction, its great Uſe 141

B.

Blood influenced by the Moon 185
Burning-Glaſſes 169

C.

Centrifugal and Centripetal Force 147, 151
Cicero, vid. *Tully*

Cold and Heat, the Cauſe of its difference in Winter and Summer Page 93
Comets, Places of Puniſhment 55, 236
———their Influences 54
———Expectations of one 55
———the Time when the next will appear 56
———their Orbs 70, 236
———the Adjuſtment of their Motion 162
———that in 1680 237
Computations of the Magnitude of the Univerſe both Ancient and Modern 8
Copernican Syſteme *Prelim. Diſc.* p. vii
———its Reaſonableneſs ibid. x
———Objections from Scripture anſwered ibid. xxi
———Objections from Senſe anſwered ibid. xxxi
———Objections from Philoſophy anſwered ibid. xxxii
Crabtrie's (Mr.) Diſpute with Mr. *Gaſcoigne* 78

D.

Day, its Benefit 88
Death depending on the Moon 185
Diamonds why made angular 129
Diviſion of the Work 6

E.

Earth's Magnitude and Meaſures 10
———not the Center of the Univerſe 39
———its Diurnal Motion 85, 148
———its Annual Motion 90
———the Benefit of theſe two Motions lying in different Paths 91

Earth's Sphericity Page 114
———the Convenience of that Figure 138
———its Hills and Valleys 117
———its Parts are well laid 133
———its Diameter 10, 117, 148
———its Centrifugal Force and Gravity 149
———its due Diſtance from and Poſition to the Sun 172
———it is a Moon to the Moon 189
Earthquakes 145
Eclipſes 186

F.

Figure of the Heavenly Bodies 111
———the Cauſe thereof 126, 142
———it is wiſely ordered 126, 128, 137
Firmament 15, 21
Fixt Stars are Suns 22, 34, 167
———their Magnitude 14
———their Diſtance 21, 52
———are innumerable 23, 30
———the Author's Obſervation of them 24
———they have Planets, 35, and *Prelim. Diſc.* xliii
———the Author's Obſervations of thoſe Planets ibid. xliii
———are duly and orderly placed 57
Force Centrifugal and Centripetal 147, 151
———the nice adjuſtment of theſe among the Planets 159

G.

Galaxy, *vid.* Milky Way
Galilæo's Experiment which anſwers the Objections againſt *Copernicus* *Prelim. Diſc.* xxxiii

Gaſcoigne's

Gaſcoigne's (Mr.) Controverſy with Mr. *Crabtrie* Page 78
Glaſſes, which are made uſe of by the Author *Prelim. Diſc.* ii.
God's Exiſtence collected from the Heavens by the Heathens 219
——his Perfection and Attributes 227
——his Relation to us, and our Duty 230
Gravity, its great Uſe 141, 153
——how to find its Proportion to the Centrifugal Force 152

H.

Heat and Cold in Summer and Winter whence 93
Heavens are Demonſtrations of God to all Nations 2
——their Immenſity 15
Heavenly Bodies are not Gods 235
——their Number 30
——their Situation 51
——they do not interfere 53
——their Proportionate Diſtances 57
——their Motion 63
——their Figure 111
Heavenly State 245

I.

Jeweller's artifice 129
Jupiter's Magnitude 12, 198
——his Orbit 20
——his Motion round his Axis 78, 198
——his Spots 82, 130
——his Period 91, 195, and *Prelim. Diſc.* x
——what his Belts are 30

Jupiter's Ambit, Centrifugal Force and Gravity Page 150
——his Light 191
——his Satellites, Days and Seaſons 197
——by whom and when diſcovered 195
——their Magnitudes, Diſtance from *Jupiter*, Periods and Latitudes 97, 200
——the Author's Obſervation of the Third 99
——their Uſes 100
——his Diſtance from the Sun 197

L.

Lactantius's Argument againſt the Divinity of the Heathen Gods 235
Light, its Neceſſity 179

M.

Magnitude of the Earth 10
——of the other Planets 11
——an Error in computing it 12
——of the Univerſe 7
Magnus Orbis a Point 52
——its Magnitude 18
Mars his Magnitude 11
——his Orbit 14
——Period 91
——his Diurnal Motion 83
——his Spots 83, 132
——his Phaſes 113
——whether he hath Satellites 194
St. *Martha*'s Mountains 119
Mercury hath no Satellites 19

INDEX.

Mercury's Phaſes Page 112
———his Magnitude 11
———his Orbit 20
———his Period 91, and *Prelim Diſc.* ix
Micrometer was invented by Mr. *Gaſcoigne* 78.
Milky Way 32
———One cauſe of its Whiteneſs according to the Author *Prelim. Diſc.* xliv
Molineux (Mr.) Reflexion 101
Moon's Magnitude 11
———the Magnitude of her Orb 17
———her Diſtance 18
———her Uſe 183
———her Influence 184
———her Light, Eclipſes, Revolution and Latitude 185
———her Phaſes 112
———her Mountains and Vallies 115, 128, 190
———how to meaſure them 120
———hath Seas 128, 189, and *Prelim Diſc.* xlviii
———her Appearance ſoon after the Full ibid. lii
———her Atmoſphere 129, 180, 189, and *Prelim. Diſc.* xlviii
———is habitable *Prelim. Diſc.* liii
Moons about the Planets 97
Motions of the Heavenly Bodies 64
———Cauſes thereof 66
———accommodated to every Globe 72
———Diurnal 76
———of the Sun round his Axis 77
———of *Jupiter* 81
——— Uſes of the Diurnal Motion 86

Motions, Periodical of the Primary Planets Pag. 89
——the Proportion thereof to their Diſtances 91
——conſtant and regular 101
Mountains very high. 117

N.

Night, its Benefit 88
Number of Heavenly Bodies 30

O.

Orbs of the Planets 20
Oyſters ſuppoſed to be influenced by the Moon 184

P.

Periacaca Mountains. 118
Phaſes in the Planets 112
Philolaus 12
Planets inhabited by what Creatures *Prelim Diſc.* liv
——their due Diſtances 51, 176
——the Proportion thereof 57, 91
——their Periodick Motion 89
——how retained in their Orbs 153
——they primarily reſpect the Sun only *Prelim: Diſc.* xiv
——they all move round their Axes ib. xvi
——they are Worlds ib. xlvii
Planets Secondary 97, 193
——their Latitudes 98
——their Uſes 191
——their Order and Periods *Prelim. Diſc.* ix
Plato's Proof of God 3, 67
Plutarch's Proof 3

Poſidonius's Sphere Page 104
Primary Mover *66*
Ptolemaick Syſteme *Prelim. Diſc.* vi
———it reaches not all the Phænomena ib. xii
———the Inconveniences of it ib. xiii
Pythagoræan Syſteme ib. vii
———the Reaſonableneſs of it ib. xii

Q.

Quickſilver, why it runs into Globules 142

R.

Rapidity of the Heavens *Prelim. Diſc.* xiv
Reckonings Ancient and Modern concerning the Extent of the Univerſe 8

S.

Saturn's Magnitude 12, 205
———Magnitude of his Orb 20
———his Period *91, 194*, 208, and *Prelim. Diſc.* x
———his Satellites 195, 203
———their Size, Diſtances, Periods and Latitudes 205
———why the fifth Satellite not ſeen always 204
———his Diſtance from the Sun 202
———his Ring 205
———the Magnitude of the Ring, Diſtance, Thickneſs, Smoothneſs and Aſpects 206, *&c.*
———the preſent Appearance of it 209
———is brighter ſometimes than others 210

Saturn's Inclination of his Axis Page 211
———his Diurnal Rotation 212
Sea purged by the Moon 185
Seneca's pious Reflexions and Arguments againſt Atheiſm 26, 224, 227
Shell-fiſh ſuppoſed to be influenced by the Moon 184
Shot, how made 142
Snowdon Hill 117
Stars, *vid.* Fixt
Stars, New, 44, 70, 90
———by whom obſerved 42
———the places where they are ſeen 44
———one now appears 43
———what they are 45
———the Author's Obſervations and Opinion 46, and *Prelim. Diſc.* xliii
———how to be obſerved ib. xlvi
Summer and Winter why differ 93
Sun's Magnitude 13
———Diſtance from the Earth 18
———Horizontal Parallax ibid.
———is a Fixt Star 37
———its Spots and Rotation 77, 91
———thought to be Hell 237
———his Heat 93, 168
———his Diſtance in Summer and Winter 95
———his Diameter ib.
———Motions in Winter ſwifter ib.
———his Ambit, Centrifugal Force and Gravity 150
———he is the Center of his Syſteme 171
———his due Diſtance from, and Poſition to the Planets 172

INDEX.

Sun's Station *Prelim. Diſc.* xix, xxviii
Syſteme of the Heavens ib. vi, xii, xxxvii
———St. *Auguſtine*'s opinion of them ib. xxx
———new, why favoured by the Author ib. xli

T.

Tenariffe Pike 118
Tides 184
Tully's Arguments for God 4, 62, 74, 104, 107, 220, 222, 224, 231
Twilight 182

V.

Venus, her Orbit 20
———her Spots and Rotation 83, 132
———her Period 91, and *Prelim. Diſc.* x
———her Phaſes 112
———her Light 191
———her Secondary Light 113
———why ſhe hath no Satellites 194
Univerſe, its Extent 39

W.

Waters are well diſpoſed 134
Winter Cold from whence 93
World not to be overvalued 372
———*Pliny*'s Reflexions thereon 240
———*Seneca*'s Reflexions on the ſame 242
———a Plurality of Worlds 40, and *Prelim. Diſc.* xlvii

THE END 7 +

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